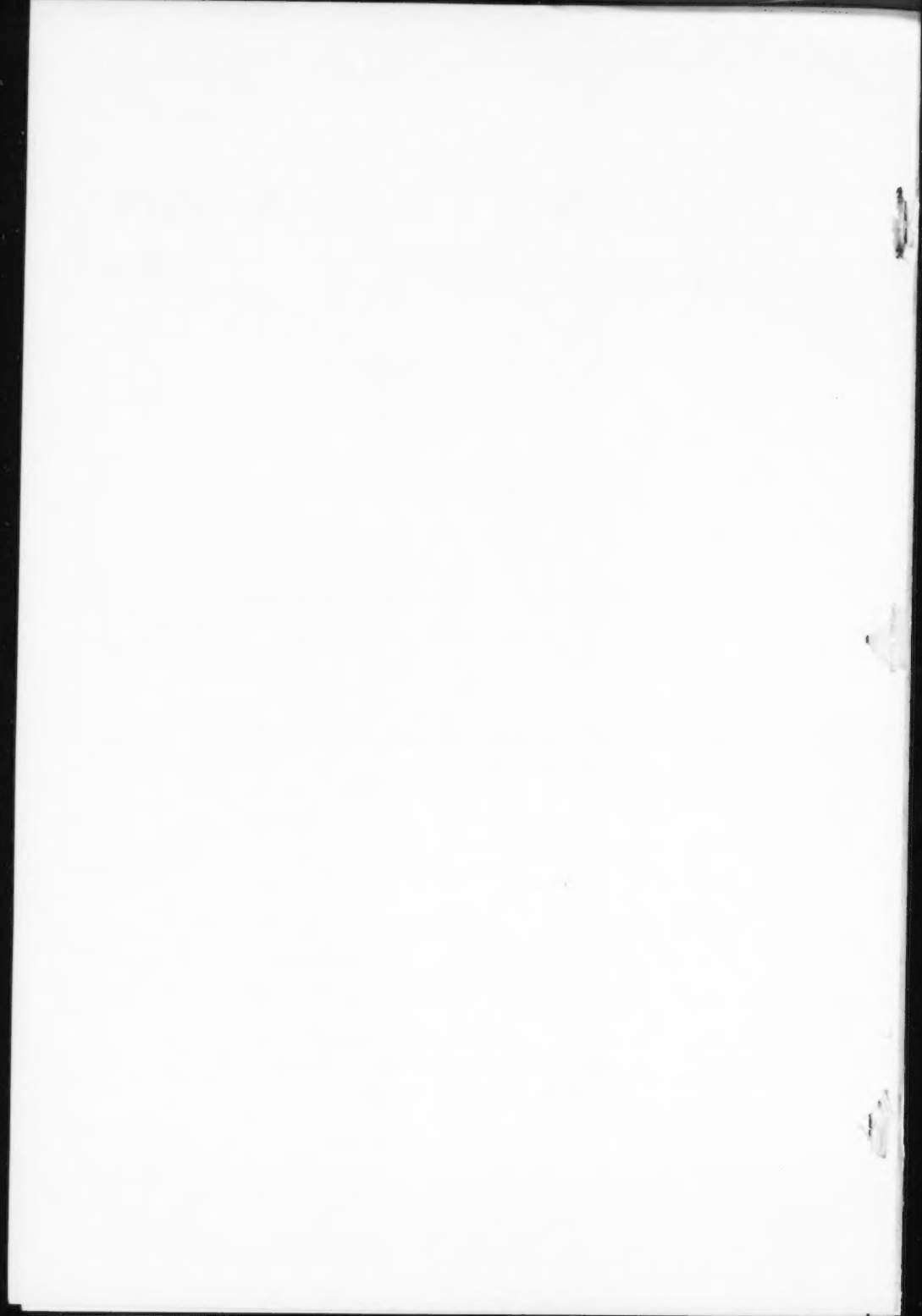# The Angle Orthodontist

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Contents

Frequency Of The Incidence Of Malocclusion In American Negro Children Aged Twelve To Sixteen

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Anatomists and physical anthropologists divide all men into three racial groups, Negro, Caucasian and Mongolian, in part on the basis of their cephalofacial features. These cephalofacial features which differentiate the races of mankind have been studied at great length by many scientists in every part of the world. In the scientific literature of our country, there is a vast wealth of information on the heads and faces of North American Caucasian children. On the other hand there is a dearth of material on the heads and faces of North American Negro children. The frequency of the incidence of malocclusion in the North American Caucasian population has been studied and recorded many times. The frequency of the incidence of malocclusion in the North American Negro population has not been recorded in the literature. As this racial group composes approximately twelve per cent of the United States' population, it seemed important and necessary to gather data on this group. This study will also seek to determine to what extent the frequency of the incidence of malocclusion in Negro children is similar to Caucasian children. This study will assess malocclusion by two different methods, one a method that is useful for epidemiologic purposes, the other, the usual method using Angle's classification which is useful for orthodontic purposes.[1,3]

Materials and Methods

A mass survey was conducted in four junior and senior high schools of the District of Columbia. The schools were selected to give a cross section of all income groups. This survey was made in conjunction with the annual dental inspection of the children in the public schools of the District of Columbia by the health department. Approximately 3500 Negro children were examined. It is felt that the size, complexity and completely homogeneous nature of this group is truly representative of this section of the North American population. From this group a selection was made of 3289 children between twelve and sixteen years of age who had only permanent teeth in their dentitions and who had received no orthodontic treatment. This was done to remove some of the variables in determining the frequency of the incidence of malocclusion. This group will henceforth in this paper be called the Howard group.

The method of examination was the method outlined by Massler and Frankel[5] in a similar study of 2758 North American Caucasian children between fourteen and eighteen years of age. These children were students

at the Morton High School of Cicero, Illinois and will henceforth in this paper be called the Illinois group. This study was chosen as representative for Caucasian children. The findings reported by Massler and Frankel on the frequency of the incidence of malocclusion according to Angle was in agreement with findings of Brucker,[2] Korkhaus,[1] McCall,[6] Munblatt,[7] Silver,[8] and Stallard.[9]

Massler and Frankel's method of examining the Illinois group consisted of examining the teeth twice; once with the mouth open and once with the teeth in occlusion. Care was taken to get the child's correct bite. During the open mouth examination each individual tooth was checked to determine its relation to the contact line. The contact line may be defined as that line connecting the contact areas of each tooth. Any tooth which was not in exact alignment was considered malpositioned. This open mouth inspection revealed those teeth that were displaced buccally, lingually or that were rotated. The teeth were next examined in occlusion. The labial and buccal views were checked in this manner and also the relationship of each tooth to the plane of occlusion. Infra and supraeruptions were checked by this examination. During the closed mouth examination the relationships of the teeth and jaws according to Angle's classification were also checked and recorded. Each malpositioned tooth was counted only once regardless of the direction or amount of displacement. Missing teeth were not counted as malpositioned, only absent. The few third molars observed were not counted.

The team of examiners were members of the Orthodontic Department of the College of Dentistry, Howard University. A special period of training was undertaken prior to this survey to review the classification of Angle and the methods of Massler and Frankel. A group of 40 children were examined separately by the three members of the team, using Angle's classification. The examiners agreed on 37 of the children, an accuracy of approximately 93 per cent. A second group of 38 children were examined by all members of the team. They agreed on the classifications of 35 children, again with an accuracy of 92 per cent. Because of the subjective nature of Angle's classification it was felt that this was a high degree of accuracy. Similar tests were made of the similarity of results using the methods of counting the total number of maloccluded teeth as suggested by Massler and Frankel.[5] The total number of teeth out of the line of occlusion either buccally, lingually, mesially, distally, rotated, infraoccluded or supraoccluded were counted. In the first group of 40 children the three examiners found the following total numbers of maloccluded teeth: 239, 241 and 244. In the second group of 38 children the totals were 227, 230 and 232. It was felt that this high degree of agreement was due to the nature of these examinations. They are much simpler and less subjective than Angle's classification.

PRESENTATION OF DATA

The data gathered by this survey will be presented separately for each sex and then the combined data. These data will then be compared with the data of Massler and Frankel.[5] The similarity of the studies of the Howard and Illinois groups and the ages of the children are sufficiently close to make these studies comparable. The ages of the children in the Howard group were from twelve to sixteen years; the ages of the children in the Illinois group were from fourteen to eighteen years. Only children with

permanent dentitions and who had received no orthodontic treatment were considered by both groups. The Illinois group were of children whose families were of the upper middle class and they were of a fairly uniform ethnic stock of North American Caucasians. The Howard group consisted of a cross section of all income groups and the children represented the great racial mixture of the North American Negro.

From the tabulation of the data gathered on the Howard group during the mass survey it was found that approximately 83 per cent of the children examined had some form of malocclusion, approximately four per cent had ideal occlusion and approximately 13 per cent had normal occlusion. The definitions of ideal and normal occlusion that were used in this study are as follows: Ideal occlusion was reserved for those cases in which not a single maloccluded tooth could be discovered; normal occlusion was used to designate those cases in which the degree of displacement was so small as to require no orthodontic treatment. Some degree of subjectivity was sometimes necessary to determine whether they belonged in the category of normal or Class I. The classification of malocclusion according to Angle was used because of its wide use by orthodontists. The definitions of the various classes were taken from the seventh edition of *Malocclusion of the Teeth* by Edward H. Angle.[1] Class I malocclusion had a mesiodistal relationship of the jaws that was characterized by a normal mesiodistal relationship of the permanent first molars. The normal mesiodistal relationship of the permanent first molars has the mesiobuccal cusp of the upper first molar fall in the mesiobuccal groove of the lower first molar. One or more teeth anterior to the molars were out of their normal positions. Class II malocclusion had the lower arch posterior to normal as

shown by the positions of the permanent first molars which were distal to normal to the extent of more than one-half the width of one cusp. This condition may have been unilateral or bilateral and had two divisions. A Class II molar relationship with protrusion of the upper incisors was called Division one and a similar case with retrusion of the upper incisors was called Division two. If the distal molar relationship existed on one side only, these divisions were called subdivisions. Class III malocclusion had the lower arch anterior to normal as shown by the positions of the permanent first molars which were mesial to normal to the extent of more than one-half the width of one cusp. Just as in Class II this classification may be unilateral or bilateral; if unilateral, they were called subdivisions. The positions of the incisors were not taken into consideration in this class.

The total number of children examined after the elimination of all who had some units of the deciduous dentition remaining or who had received orthodontic treatment was 3289; 1470 were males and 1819 were females. The totals in each classification according to Angle were as follows: ideal occlusion — 68 or 3.69 per cent of the females, 53 or 3.61 per cent of the males, 121 or 3.69 per cent when combined; normal occlusion — 230 or 12.64 per cent of the females, 191 or 12.99 per cent of the males, 421 or 12.79 per cent when combined; Class I — 1,188 or 65.31 per cent of the females, 996 or 67.75 per cent of the males, 2,184 or 66.40 per cent when combined; Class II, Division 1 — 196 or 10.77 per cent of the females, 151 or 10.27 per cent of the males, 347 or 10.55 per cent when combined; Class II, Division 2 — 35 or 1.92 per cent of the females, 17 or 1.16 per cent of the males, 52 or 1.58 per cent when combined; Class III — 100 or 5.50 per

HOWARD UNIVERSITY MASS SURVEY DATA

TABLE 1. DISTRIBUTION OF OCCLUSION ACCORDING TO ANGLE'S CLASSIFICATION
(FEMALES)

AGE IN YEARS	NUMBER OF CHILDREN EXAMINED	"GOOD" OCCLUSION				MALOCCLUSION							
		"IDEAL" OCCLUSION		"NORMAL" OCCLUSION		CLASS I		CLASS II DIV. 1		CLASS II DIV. 2		CLASS III	
		No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
12	331	13	(3.92)	46	(13.89)	209	(63.41)	41	(12.39)	3	(0.906)	19	(5.74)
13	378	13	(3.41)	48	(12.70)	249	(65.87)	50	(13.23)	4	(1.058)	20	(5.29)
14	436	18	(4.13)	38	(8.71)	292	(66.97)	46	(10.55)	6	(1.376)	25	(5.73)
15	375	12	(3.20)	59	(15.73)	241	(64.27)	39	(10.40)	8	(2.13)	18	(4.80)
16	299	12	(4.01)	39	(13.05)	197	(65.89)	20	(6.69)	14	(4.68)	18	(6.02)
12 to 16	1,819	68	(3.69)	230	(12.64)	1,188	(65.31)	196	(10.77)	35	(1.92)	100	(5.50)

HOWARD UNIVERSITY MASS SURVEY DATA

TABLE II.　DISTRIBUTION OF OCCLUSION ACCORDING TO ANGLE'S CLASSIFICATION
(MALES)

AGE IN YEARS	NUMBER OF CHILDREN EXAMINED	"GOOD" OCCLUSION		MALOCCLUSION			
		"IDEAL" OCCLUSION No. (%)	"NORMAL" OCCLUSION No. (%)	CLASS I No. (%)	CLASS II DIV. 1 No. (%)	CLASS II DIV. 2 No. (%)	CLASS III No. (%)
12	206	10 (4.85)	23 (11.16)	133 (64.56)	32 (15.53)	2 (0.971)	6 (2.91)
13	335	12 (3.57)	53 (15.77)	213 (63.39)	33 (9.82)	1 (0.298)	18 (5.36)
14	357	11 (3.08)	44 (12.60)	261 (73.10)	31 (8.68)	4 (1.12)	17 (4.76)
15	335	12 (3.58)	43 (12.83)	232 (69.25)	30 (8.96)	5 (1.49)	11 (3.28)
16	236	8 (3.39)	28 (11.86)	157 (66.53)	25 (10.59)	5 (2.12)	12 (5.08)
12 to 16	1,470	53 (3.61)	191 (12.99)	996 (67.75)	151 (10.27)	17 (1.16)	64 (4.35)

HOWARD UNIVERSITY MASS SURVEY DATA

TABLE III. DISTRIBUTION OF OCCLUSION ACCORDING TO ANGLE'S CLASSIFICATION
(MALES AND FEMALES COMBINED)

AGE IN YEARS	NUMBER OF CHILDREN EXAMINED	"GOOD" OCCLUSION				MALOCCLUSION								
		"IDEAL" OCCLUSION*		"NORMAL" OCCLUSION**		CLASS I		CLASS II DIV. 1		CLASS II DIV. 2		CLASS III	
		No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
12	537	23	(4.28)	69	(12.85)	342	(63.69)	73	(13.59)	5	(0.931)	25	(4.66)
13	714	25	(3.50)	101	(14.15)	462	(64.71)	83	(11.62)	5	(0.70)	38	(5.32)
14	793	29	(3.65)	82	(10.34)	553	(69.74)	77	(9.71)	10	(1.26)	42	(5.30)
15	710	24	(3.38)	102	(14.38)	473	(66.62)	69	(9.72)	13	(1.83)	29	(4.08)
16	535	20	(3.73)	67	(12.52)	354	(66.17)	45	(8.41)	19	(3.55)	30	(5.61)
12 to 16	3,289	121	(3.69)	421	(12.79)	2,184	(66.40)	347	(10.55)	52	(1.58)	164	(4.99)

* "Ideal" occlusion was reserved for those cases in which not a single maloccluded tooth could be discovered.

** "Normal" occlusion was used to designate those cases in which the degree of displacement was so small as to require no orthodontic treatment. Some degree of subjectivity was necessary in some cases in order to determine whether they belonged in the category of "normal" or "class I."

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TABLE IV. DISTRIBUTION OF OCCLUSION ACCORDING TO ANGLE'S CLASSIFICATION
(MALES AND FEMALES COMBINED)

| AGE IN YEARS | NUMBER OF CHILDREN EXAMINED | "GOOD" OCCLUSION | | MALOCCLUSION | | | |
		"IDEAL" OCCLUSION* No. (%)	"NORMAL" OCCLUSION** No. (%)	CLASS 1 No. (%)	CLASS II DIV. 1 No. (%)	CLASS II DIV. 2 No. (%)	CLASS III No. (%)
14	553	21 (3.80)	98 (17.72)	283 (51.17)	85 (15.37)	14 (2.53)	52 (9.40)
15	728	19 (2.61)	125 (17.17)	367 (50.41)	129 (17.73)	27 (3.70)	61 (8.38)
16	698	21 (2.89)	135 (19.34)	341 (48.85)	113 (16.21)	19 (2.17)	69 (9.90)
17	654	19 (2.91)	118 (18.05)	327 (50.00)	112 (17.15)	14 (2.14)	64 (9.79)
18	125	1 (0.80)	25 (20.00)	63 (50.40)	21 (16.80)	1 (0.80)	14 (11.20)
14 to 18	2,758	81 (2.93)	501 (18.23)	1,381 (50.07)	460 (16.68)	75 (2.71)	260 (9.43)

* "Ideal" occlusion was reserved for those cases in which not a single maloccluded tooth could be discovered.

** "Normal" occlusion was used to designate those cases in which the number of maloccluded teeth was less than the average number (10) and the degree of displacement was so small as to catalog it clinically as "normal" and re-quiring no treatment. Some degree of subjectivity was necessary in such cases in order to determine whether they belonged in the category of "normal" or "mild class I." For the most part the decisive factor was whether or not orthodontic treatment was or was not indicated.

Data for males and females were also computed separately. The findings were not significantly different.

HOWARD UNIVERSITY MASS SURVEY DATA

TABLE V. NUMBER OF MALOCCLUDED TEETH IN CHILDREN FROM 12 TO 16 YEARS OF AGE

AGE IN YEARS	NUMBER OF CHILDREN EXAMINED			TOTAL NUMBER OF MALOCCLUDED TEETH			AVERAGE NUMBER OF MALOCCLUDED TEETH PER CHILD		
	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined
12	206	331	537	1,268	1,600	2,868	6.16	4.83	5.34
13	336	378	714	2,074	2,251	4,325	6.17	5.96	6.06
14	357	436	793	2,246	2,459	4,705	6.29	5.64	5.93
15	335	375	710	2,127	2,342	4,469	6.35	6.25	6.29
16	236	299	535	1,470	1,835	3,305	6.23	6.14	6.18
12 to 16	1,470	1,819	3,289	9,185	10,487	19,672	6.25	5.76	5.98

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TABLE VI. NUMBER OF MALOCCLUDED TEETH IN CHILDREN FROM 14 TO 18 YEARS OF AGE

AGE IN YEARS	NUMBER OF CHILDREN EXAMINED			TOTAL NUMBER OF MALOCCLUDED TEETH			AVERAGE NUMBER OF MALOCCLUDED TEETH PER CHILD		
	Male	Female	Combined	Male	Female	Combined	Male	Female	Combined
14	209	344	553	2,378	3,467	5,845	11.38	10.08	10.56
15	314	414	728	3,318	4,465	7,783	10.57	10.78	10.69
16	331	367	698	3,578	3,470	7,048	10.81	9.45	10.09
17	303	351	054	3,353	3,685	7,038	11.07	10.50	10.76
18	81	44	125	945	444	1,389	11.67	10.99	11.11
14 to 18	1,238	1,520	2,758	13,572	15,531	29,103	10.96	10.22	10.55

cent of the females, 64 or 4.35 per cent of the males, 164 or 4.99 per cent when combined. Inspection of these totals shows that there was no significant difference in the frequency of the incidence of malocclusion for males and females. The data for females are presented in Table I; for males in Table II; and the data for the combined sexes in Table III.

Similar data using Angle's classification were taken from the study of the Illinois group and the following totals were found: 2758 children were examined and of this number 1238 were males and 1520 were females. Massler and Frankel[5] found that the differences in the data for males and females were not significant and only the combined data are presented here. These data are presented in Table IV. Ideal occlusion — 81 or 2.93 per cent; normal occlusion — 501 or 18.23 per cent; Class I — 1381 or 50.07 per cent; Class II, Division 1 — 460 or 16.68 per cent; Class II, Division 2 — 75 or 2.71 per cent; Class III — 260 or 9.43 per cent.

The data compiled according to the number of maloccluded teeth per child were analyzed for the Howard group. These teeth were out of normal alignment either occlusally, gingivally, mesially, distally, buccally, lingually or rotated. These data are presented in Table V and the totals are as follows: 3289 Negro children had 19,672 maloccluded teeth; of these the 1470 males had 9185 maloccluded teeth or 6.25 maloccluded teeth per male child; and

the 1819 females had 10,487 maloccluded teeth or 5.76 maloccluded teeth per female child. Here again we have no significant difference between the sexes in the frequency of the incidence of the number of maloccluded teeth. We had approximately six maloccluded teeth for each child. Similar data gathered on the Illinois group had the following totals: 2758 Caucasian children had 29,103 maloccluded teeth; of these the 1238 males had 13,572 maloccluded teeth or 10.96 maloccluded teeth per male child; the 1520 females had 15,-531 maloccluded teeth or 10.22 maloccluded teeth per female child. These data are presented in Table VI. There was no significant difference in the frequency of the incidence of maloccluded teeth between the sexes. The combined or average number of maloccluded teeth for the Illinois group was approximately 10 maloccluded teeth for each child.

DISCUSSION

The totals for good occlusion for both studies according to Angle are in Table VII.

It can be seen from the above table that the frequency of the incidence of ideal occlusion, a classification of near perfection with not a single tooth in malocclusion, is small in both studies — 3.69 per cent in the Howard group and 2.93 per cent in the Illinois group. The percentage of children with normal occlusion is seen to vary in this table 12.79 per cent in the Howard group and 18.23 per cent in the Illinois

TABLE VII

"GOOD" OCCLUSION

	AGE IN YEARS	NUMBER OF CHILDREN EXAMINED	"IDEAL" OCCLUSION (%)	"NORMAL" OCCLUSION (%)
Howard	12 to 16	3,289	3.69	12.79
Illinois	14 to 18	2,758	2.93	18.23

TABLE VIII

MALOCCLUSION

	CLASS I	CLASS II DIV. 1	CLASS II DIV.2	CLASS III
	%	%	%	%
Howard	66.40	10.55	1.58	4.99
Illinois	50.07	16.68	2.71	9.43

group. A possible explanation of this difference may be found in the methods used in classifying normal occlusion by both studies. The Illinois group used a numerical system of determining normal occlusion, namely, a dentition with an average number of less than ten slightly maloccluded teeth was called normal. In the Howard study no thought was given to an average number of maloccluded teeth, but only the consideration as to whether orthodontic treatment was needed. But it must be admitted that some degree of subjectivity is necessary to determine whether some of the cases belonged in the category of "normal" or "Class I." This degree of subjectivity will vary between any two groups of investigators.

The frequency of the incidence of malocclusion according to Angle's classification in both studies is given in the Table VIII.

It can be seen upon comparing the frequencies of the incidence of the various classes of malocclusion that the following differences exist. Class I malocclusion had 66.40 per cent in the Howard group and 50.07 per cent in the Illinois group. We feel this difference of 16 per cent to be significant. Class II, Division 1 malocclusion had 10.55 per cent in the Howard group and 16.68 per cent in the Illinois group. There seem to be significantly fewer children with this form of malocclusion in the Howard group. Class II, Division 2 malocclusion had 1.58

per cent in the Howard group and 2.71 per cent in the Illinois group. The frequency of the incidence in both groups was small and similar. Class III had 4.99 per cent in the Howard group and 9.43 per cent in the Illinois group. There are significantly fewer children with this form of malocclusion in the Howard group. We feel that this information relative to the differences in the frequencies of the incidence of Class II, Division 1 and Class III malocclusion in the Howard group is related to larger tooth and arch size as well as the differences in the configuration of the head and face of these two groups. A comparison of the average number of maloccluded teeth showed approximately six in the Howard group and approximately ten in the Illinois group.

SUMMARY AND CONCLUSIONS

A study has been made of the frequency of the incidence of malocclusion in the North American Negro child population. 3289 Negro children were examined in the public schools of the District of Columbia. These children were between twelve and sixteen years of age; they had only permanent dentitions and had received no orthodontic treatment. It is felt that the size, complexity and completely homogeneous nature of this sample is representative for the great racial mixture of the North American Negro.

The frequency of the incidence of malocclusion was assessed by two methods: one was a method that is

useful for epidemiologic purposes, i.e., simply counting the teeth that were out of the normal alignment or occlusion, the other was the usual method using the classification of Angle. Comparisons were made between the frequencies of the incidence of malocclusion in Caucasian children and Negro children. The study made by Massler and Frankel was chosen as a representative study of North American Caucasian children.

The Howard study has shown that:

1. The frequency of the total incidence of malocclusion is high in the Negro child population. Approximately eighty-three per cent of the children had malocclusion of their teeth. About four per cent had ideal or nearly perfect occlusion and thirteen per cent had normal occlusion, i.e., they had some teeth slightly malpositioned but not sufficiently so as to require orthodontic treatment.

2. The frequency of the total incidence of malocclusion in the Negro child population is comparable to the frequency of the total incidence of malocclusion in the Caucasian child population. This total incidence as reported by Massler and Frankel and many other authors is that approximately eighty per cent of American Caucasian children have malocclusion of their teeth. Only three per cent have ideal occlusion and approximately eighteen per cent have normal occlusion, i.e., they have some teeth slightly malpositioned but not sufficiently so as to require orthodontic treatment.

3. There seem to be fewer maloccluded teeth per child in the Negro child population than in the Caucasian child population.

There were approximately six maloccluded teeth per child in the Howard group and ten maloccluded teeth per child in the Illinois group.

4. There are differences in the frequency of the incidence of the various classes of malocclusion according to Angle among North American Negroes and Caucasians. There were fewer Negro children with normal, Class II, Division 1 and Class III malocclusion. Further studies to determine possible reasons for these differences will be reported at a later date.

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Unilateral Cervical Traction With A Kloehn Extraoral Mechanism

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There exists a lack of understanding regarding the production of unilateral cervical traction with a Kloehn extraoral mechanism. The present method of offsetting the joint between the extraoral and oral bows is not theoretically correct unless the joint is a knife-edge. In the following material two steps are presented which can be utilized to achieve unilateral action. These steps do not involve changes in the location of the joint between the two bows. Instead, the aim is to alter the positions of the lines of action of the applied forces so that the line of action of the resultant lies closer to the molar against which greater force action is desired.

Figure 1 represents a plan view of a Kloehn mechanism. Points m and n of the oral bow are inserted into buccal tubes attached to the upper first molars. Points j and k serve as attachments for an elastic cervical strap which sup-

plies the force for tooth movement. The arrows are vectors which signify the magnitudes and directions of the applied forces acting in the plane of the mechanism. The T vectors represent the pull of the cervical strap and, since this strap is continuous, the forces at j and k are equal in magnitude. Vectors F_L and F_R represent the reactive forces exerted by the buccal tubes against the oral bow. Since action and reaction are equal, the oral bow exerts F_L and F_R against the buccal tubes and through these against the molars. If the molars are tied to the other teeth of the maxillary arch, the entire arch is, of course, subjected to F_L and F_R.

To illustrate the system of forces active in cervical traction, it becomes necessary to write general mathematical expressions of the physical conditions which must be satisfied to produce static equilibrium of the appliance. One of these physical conditions is that the sum of the forces parallel to F_L and F_R must be zero. This is just another way of stating that the forces must be in balance. Thus from Figure 1:

1. $F_L + F_R - 2T \cos \Theta = 0$

A second physical condition to be met is that the sum of the moments of the forces about any point in the plane of the forces must be zero. It may be remembered that a moment of a force is the product of the magnitude of the force and the perpendicular distance from a given point to the line of action of the force. In symbols, taking

Fig. 1, Plan view of a Kloehn extraoral mechanism. Points m and n enter buccal tubes. A cervical elastic strap is attached to points j and k.

moments about point m:

2. $F_R \times B + T \cos \Theta \times A + T \sin \Theta \times C$
$- T \cos \Theta \times (A + B) - T \sin \Theta \times C = O$

When these equations are solved simultaneously for the two unknown quantities, F_L and F_R, it will be found that $F_L = F_R$. This result is in keeping with the common experience that a symmetrical system of forces produces uniform force action against the buccal tubes. It may seem unnecessary to utilize equations 1 and 2 to arrive at this simple conclusion; however, these equations are important because they show which physical quantities affect the action of the appliance.

A mathematical background is not needed to recognize the quantities in equations 1 and 2. Forces T, F_L and F_R are present as are dimensions A, B and C. Also of importance is the direction of T with respect to the sagittal plane (forces F_L and F_R are assumed to be parallel to the sagittal plane). The location of the joint at O, on the other hand, does not enter into either equation. This joint is invariably soldered, welded, or banded and it must be considered as being rigid. Even when this joint consists of a pin and tube, it resists bending in the plane of the appliance. Since this joint is rigid, it does not represent a point where external forces are applied. In other words the extraoral and oral bows comprise a single unit and the location of the union between them has no significance as far as external force action is concerned. It is well known in mechanics that the external effects of a force on a body are not influenced by the shape of the body. In any force system attention must be focused on the magnitudes of the forces, on the positions of the lines of action of the forces and on the directions of the forces along their respective lines of
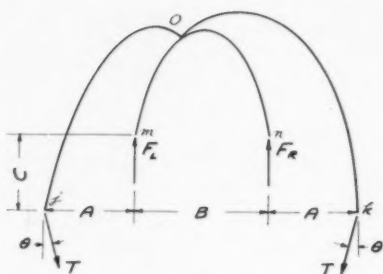

Fig. 2, The joint at O between the oral and extraoral bows has been offset to the left from its central position shown in Fig. 1.

action. The performance of any appliance is governed by these characteristics and not by appliance configurations as such.

As an example of the above principles reference is made to Figure 2. Here the shape of the appliance has been changed by offsetting the joint to the left of its original central position. This is the technique commonly used with the intention of increasing the load against one buccal tube while decreasing the load against the other. In short, unilateral action is supposed to be established. Inspection of Fig. 2, however, will reveal that this procedure has not altered any of the lines of action, directions or magnitudes of the applied forces. Equilibrium equations for this appliance would be exactly as before with the result that F_L and F_R must be equal. Thus, offsetting the soldered joint is not the road to unilateral action because this does not change the relationship between the applied and the reactive forces. An offset would work if the rigid joint were replaced by a knife-edge type of connection so that no torque or bending moment could be transmitted through O. In that case O becomes a point at which an external force is applied. Obviously, it would be impossible to utilize a knife-

edge connection between the extraoral and oral bows in clinical orthodontics.

The above principles suggest a method by which the reactions F_L and F_R could be made unequal. For example, if it is desired to subject the right buccal tube to a greater force than the left, some way must be found to bring the line of action of the resultant of the T forces closer to the right than to the left tube. The resultant of the T forces is the single force having the same external effect as the two T forces.
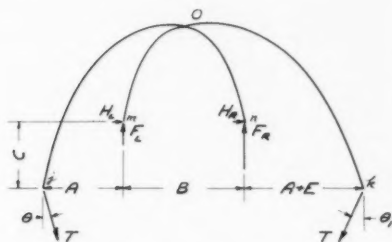

Fig. 3, Point k has been displaced laterally to the right an amount E. The angles between the cervical strap and the sagittal plane are no longer equal on both sides.

To displace the line of action of the resultant to the right, it is necessary to displace the lines of action of the T forces to the right. Because of physical limitations it is not possible to displace j to the right, but it is feasible to do so with k. This has been done in Figure 3 where k has been moved laterally to the right an amount E. The solution of appropriate equilibrium equations will show that this step will increase F_R by an amount approximately proportional to $T \times \frac{E}{B}$ and decrease F_L by a similar amount. If E could be made large enough, total unilateral action could be realized by this step alone. Unfortunately, it is seldom possible to increase E beyond a value of about three fourths of an inch because of the likelihood that the appliance
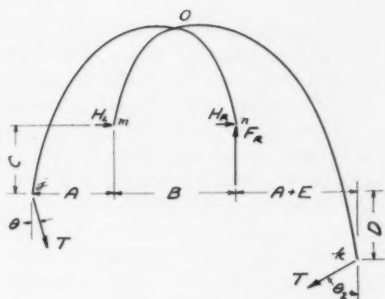

Fig. 4, The right arm of the mechanism has been lengthened an amount D relative to the left arm. Point k is displaced to the right an amount E.

will be dislodged during sleep. This limitation requires the introduction of a second step, first used at the University of Nebraska,[1] which is shown in Figure 4. Here the right arm of the face bow has been lengthened by an amount D. Such lengthening has the effect of rotating the resultant clockwise thereby bringing its line of action even closer to the right buccal tube. Equilibrium equations based on Figure 4 give the following:

$$3.\ F_R = \frac{T \cos \Theta_2 \times (B + A + E)}{B}$$
$$+ \ \frac{T \sin \Theta_2 \times (C + D)}{B}$$
$$- \ \frac{T \cos \Theta \times A}{B} - \frac{T \sin \Theta \times C}{B}$$
$$4.\ F_L = T (\cos \Theta + \cos \Theta_2) - F_R$$

Now, if numerical values are substituted for A, B, C, D, E, T and Θ, the magnitudes of F_L and F_R can be calculated. Averages of a large number of measurements based on appliances in use can be used for typical values of the above quantities. With the inch as a unit of length and letting A = 1⅜, B = 2¼, C = ¼, D = 1¾, E = ¾, Θ = zero degrees, Θ₂ = 48 degrees, and T = 1 pound, it will be found that F_R equals approximately 1.4 lbs. and F_L equals about 0.3 lbs.

Thus, under these conditions the right buccal tube receives more than four and one half times the load received by the left buccal tube. Further increases in D and E would continue to increase F_R and decrease F_L. Finally a point will be reached where F_R represents all of the distally directed force. In fact, if D and E are made too large, the appliance will be pulled out of the left buccal tube since the left reaction must become negative. In this case the line of action of the resultant lies to the right of the right buccal tube.

If Figures 3 and 4 are re-examined, lateral forces H_L and H_R will be observed which do not appear in Figures 1 and 2. These forces are introduced by the inequality of angles Θ, Θ_1, and Θ_2. As soon as D and E appear, the cervical strap no longer makes equal angles with the sagittal plane on the right and left sides. Plainly, $T \sin \Theta$ does not equal $T \sin \Theta_1$ or $T \sin \Theta_2$. The sum of H_L and H_R must equal the difference between $T \sin \Theta_1$ and $T \sin \Theta$ or $T \sin \Theta_2$ and $T \sin \Theta$. H_L and H_R are generally undesirable except in the case where an appropriate crossbite is to be corrected simultaneously.

Discussion

In actual practice it is exceedingly difficult, if not impossible, to rationally design an appliance so that in a given case the total distally directed force is placed on one or the other molar. Fortunately, it is not necessary to work with exact forces in orthodontics and, without this restriction, it is relatively simple to incorporate dimensions D and E, consistent with the geometry of the face and tolerance of the patient, to create useful unilateral action. Experience has shown that the maxillary teeth on one side of the arch can be effectively retracted through the use of this method.

Frequently the patient will fail to verify unilateral action. There may be several reasons for this. One of the most common causes is that friction between the elastic neck strap and the neck temporarily offsets the equality of the applied forces at j and k. This is easily overcome by several movements of the head from side to side or by running a finger between the strap and neck. Another cause can be traced to excessive flexibility of the face bow which permits the final or seated values of A, C, D, and E to become different from the desired or planned values. It should be emphasized that dimensions A, D, and E are seated dimensions and represent distances when the appliance is being subjected to external forces. Usually the flexibility of the appliance is such that these dimensions are somewhat altered when the appliance is changed from the passive to the active state. To minimize error from this source, the use of large diameter wire for the extraoral bow is recommended. Finally, binding between the appliance and the buccal tubes can lead to unpredictable results. Such binding adds forces not shown in Figures 1 to 4 and these forces may either increase or decrease the unilateral effect depending on their directions. It is essential that the appliance fits passively into the buccal tubes to avoid the introduction of these forces or couples.

The above precautions hold also for symmetrical cervical traction. Any one or combination of these factors can produce partial unilateral action when it is not wanted. Usually the patient will voluntarily state that he doesn't feel any pressure on one side or the other. A check for neck friction, lack of symmetry of the lines of action of the applied forces with respect to the dental arch because of excessive flexibility of the appliance, and binding

within the tubes will probably locate the reason for the non-uniform action.

SUMMARY

A method for establishing unilateral cervical traction with a Kloehn-type of extraoral mechanism has been described. This involves the lateral displacement and lengthening of the arm of the face bow on the strong side relative to the arm on the weak side. The amount of this lateral displacement and lengthening will vary from case to case depending on the facial dimensions, tolerance of the patient and the amount of unilateral action wanted. Total or very nearly total unilateral action can be created, in the average case, when the lateral displacement is about three fourths of an inch and when the strong arm of the face bow is about two inches longer than the weak arm. These dimensions pertain to the active state of the appliance. Although this technique is quite effective in producing unilateral distal forces, it has the disadvantage of simultaneously subjecting the dental arch to side or lateral forces. These would be useful only in certain crossbite cases.

Study of unilateral action with the Kloehn extraoral mechanism also throws light on some of the reasons why unequal forces are sometimes experienced when uniform bilateral action is actually wanted. If the patient fails to verify the type of action desired, a check should be made to see that the appliance fits freely into the buccal tubes, that the appliance is not deformed excessively when it is seated and that the forces provided by the neck strap are not temporarily unbalanced due to frictional forces between the strap and the neck.

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Potentials In The Pattern

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The persistence and the potential of the growth pattern of the human head and jaws continue to intrigue me. Therefore, I am constantly on the alert for additional evidence to support or refute my contention that the morphogenetic pattern is unique for each individual and persists over any treatment procedure. The pattern is: (1) spatial, (2) morphogenetic, (3) functional and (4) psychologic.

By pattern I mean a conglomeration (or juxtaposition) of factors which are fixed for the individual. These factors are multidimensional in that not only is the pattern spatial in extent, but also morphogenetic in that heredity puts its permanent stamp on it. It is also functional and psychologic. By psychologic I refer to the patient's behavioral response, namely cooperation. The concept is broad but its emphasis is on limitations. Furthermore, its potential is not known until full growth and development are achieved.

For quite some time a good deal of thought and discussion has been given to the contention that, in order to achieve a successfully treated case, anchorage must first be prepared. This thought seems to be even more prevalent in extraction cases. This preparing of anchorage and its results were assessed cephalometrically in a case which I treated in 1940 and gave to Dr. Brodie to report in his paper on the extraction panel.[1] Subsequently I was fortunate enough to secure additional records some years later which I wish to present here.

Case L.L. was a severe Class II, Division I malocclusion as seen by the tracing taken from a lateral head x-ray (solid line) showing the case before treatment (Fig. 1).

For the first four months the lower teeth were subjected to tip-back bends together with ligature traction and arch expansion. Figure 1 represents a superposed tracing of the original and one made at the end of that phase of treatment. All superpositions have been on the SN plane registered at S. This reveals that, although the lower incisor has been tipped lingually, the molar crown has not gone back, but the root apices have come forward to an appreciable degree. It shows further that the arch has been shortened anteroposteriorly, which shortening could have been gained only by lateral expansion. The Hawley arch form was used as the guide to the shape of the arch.

At this period Class III elastics were applied to complete the distal movement. After one month the clinical evidence of forward movement of the upper was so pronounced that a headcap with occipital force was applied to this arch. Figure 2 shows what was accomplished over the next three and a half months. It will be noted that the maxillary molar has been elevated, the usual response to pull of Class III elastics. The maxillary incisor has been retracted somewhat through a shortening of this arch. The posterior end of the occlusal plane has opened the bite as indicated by the new position (posteriorly) of the mandible. This completed the first phase or anchorage preparation.

L.L.
········ 13-1-9
———— 13-7-27
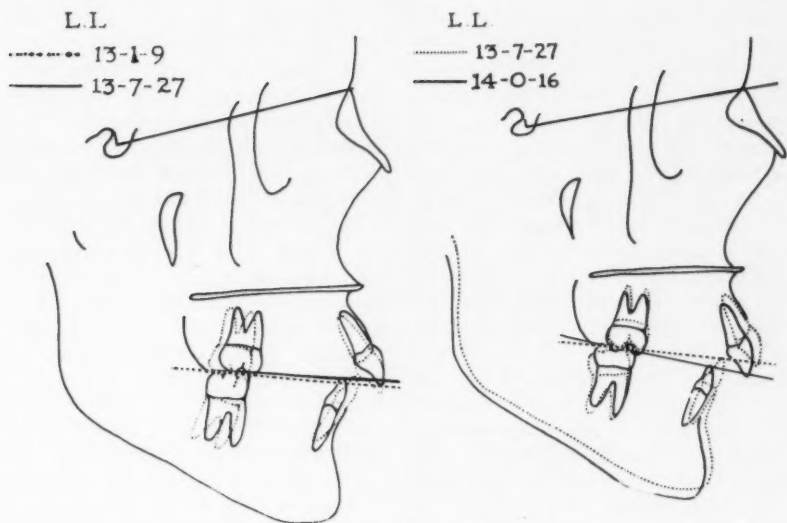
L.L.
············ 13-7-27
———— 14-0-16

Fig. 1, Left. Fig. 2, Right.

The next and final phase of treatment called for the setting back of the maxillary arch. This was accomplished with second order bends and Class II intermaxillary elastics with a headcap worn against the upper at night to support the elastics. This required approximately six months and is represented by the findings at age 14-5-27. Although the mesiodistal correction had been accomplished, another three to four months were used in settling and finishing the case.

Figure 3 represents a comparison between the first tracing and one made at the end of active treatment. It reveals that both molars are slightly forward of their original positions, the lower more than the upper. The upper incisors have been carried downward and lingually. The occlusal plane has been tipped down in front, and the mandible has been forced inferiorly and posteriorly.

The lower molar, on the other hand, has gone upward one-third of its crown

height and forward one-third of its mesiodistal width. The arch has been shortened by expansion and the molar now occupies a more unfavorable position than it did originally. Thus, at the end of a long period of treatment,
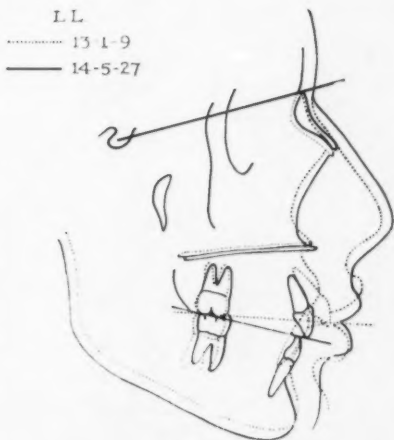
L.L.
············ 13-1-9
———— 14-5-27

Fig. 3.

with considerable disturbance of axial inclinations, we find the case in a more unstable condition than it would have been had it been treated in an orthodox manner.

Figure 4 is a composite of two tracings showing the case two years later at the end of the retention period. We see here a downward and forward growth of the mandible of considerable extent. There is a downward and forward position of the lower incisor which has maintained practically its same axis.

The lower molar which at the end of active treatment was apparently tipped distally, is now beginning to assume a more upright position as it moves downward and forward under the growth influence.

There is a distinct change of the axis of the upper incisor, with the crown down and forward and the root apex pointing lingually again. The upper molar shows a similar change of its axis with the crown down and forward. Notice the recovery of the

occlusal plane, the result of the improved axes of the teeth.

We note also a tremendous surge in overall growth with parallel downward and forward growth of the nasal floor and a forward position of nasion with an accompanying increase in the size of nasal bone and the nose.

Figure 5 is a comparison between the tracing of 16 years, 6 months and one taken at 23 years, 6 months, and shows a continuation of the overall growth picture which is a male characteristic. The occlusal plane has remained nearly parallel, as have the axes of the incisors and molars. Notice the combined forward growth of nasion with a tremendous increase in the size of the nasal bone and the nose, and observe how the nasal floor has maintained a parallel position.

Figure 6 represents cephalometric tracings of the mandibles of Case L.L. superimposed on the symphyses. The result of active treatment (upper left) shows that the occlusal plane has been elevated; the molar has gone forward
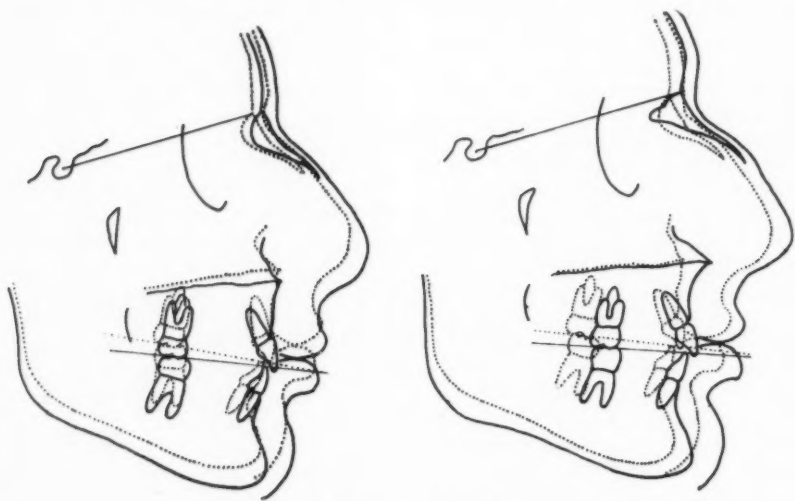

Fig. 4, Left. Fig. 5, Right.

LL
...... 13-1-9
—— 14-5-27

LL
...... 14-5-27
—— 16-6-7

LL
...... 16-6-7
—— 23-6-7
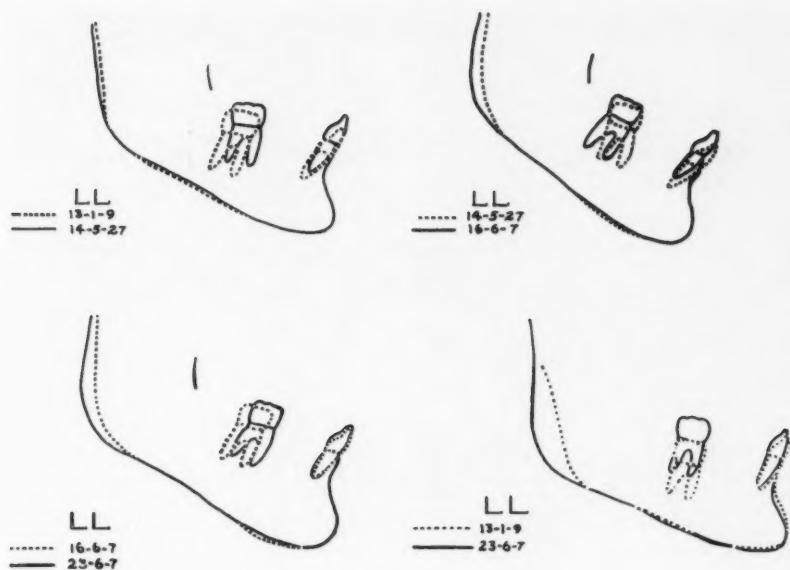
LL
...... 13-1-9
—— 23-6-7

Fig. 6. Mandibular superpositions.

and rotated on its axis. Note that, although the incisor is elevated, the axial inclination is practically unchanged. The anchorage preparation which was supposed to tip back the incisor appears to have succeeded only in displacing the molar.

What looks like anchorage preparation may be a distal positioning or tipping of the mandible, giving an upright flat appearance to the incisor area.

During retention (upper right) we see a definite return of the molar to its former axial position. The incisor axis has been practically maintained. The occlusal plane has returned to a more level position and has elevated.

In the lower left composite is depicted the changes from 16 years, 6 months to 23 years, 6 months. There is some growth at the posterior border. The lower molar is forward slightly while the occlusal plane moved up-
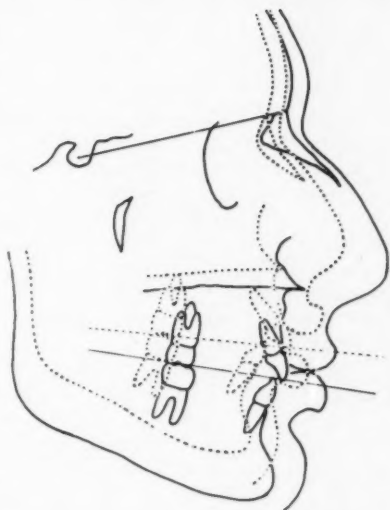

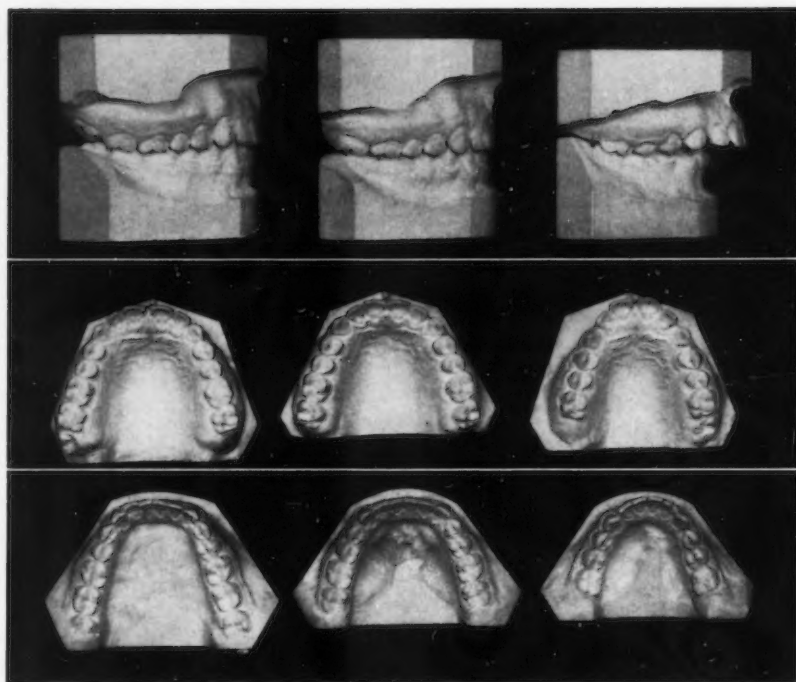Fig. 7. Dotted, before treatment; solid, ten years later.

Fig. 8. Right to left, models before treatment, at completion of retention, and seven years after treatment.

ward chiefly in the molar area.

We now go one step farther and examine the original case at age thirteen before treatment and at age twenty-three. Figure 7 represents a composite of the tracings of those years and reveals the following:

(a) An enormous overall growth, especially in the mandible; a downward and forward growth of the entire face along the Y axis.

(b) Extreme forward position of nasion, together with marked increase in nasal bone.

(c) Downward movement of the nasal floor in a distinctly parallel manner.

(d) The occlusal plane has returned almost to the original. In fact it has opened slightly in the anterior region.

(e) The axes of the molars and incisors are nearly identical; in fact, the incisor at the end of this ten year interval is slightly more upright than it was at the beginning of treatment.

Figure 8 represents original models, those at the end of retention, and those taken 7 years later at age 23 years 6 months; they illustrate how the case has maintained itself. In fact, the models taken at age sixteen years can be transposed on those taken at age twenty-three years. Figure 9 shows photos originally, at end of active treatment and at end of retention. Figure 10 is a profile photograph at 23 years — the frontal photograph was not available. The balanced face speaks for itself.
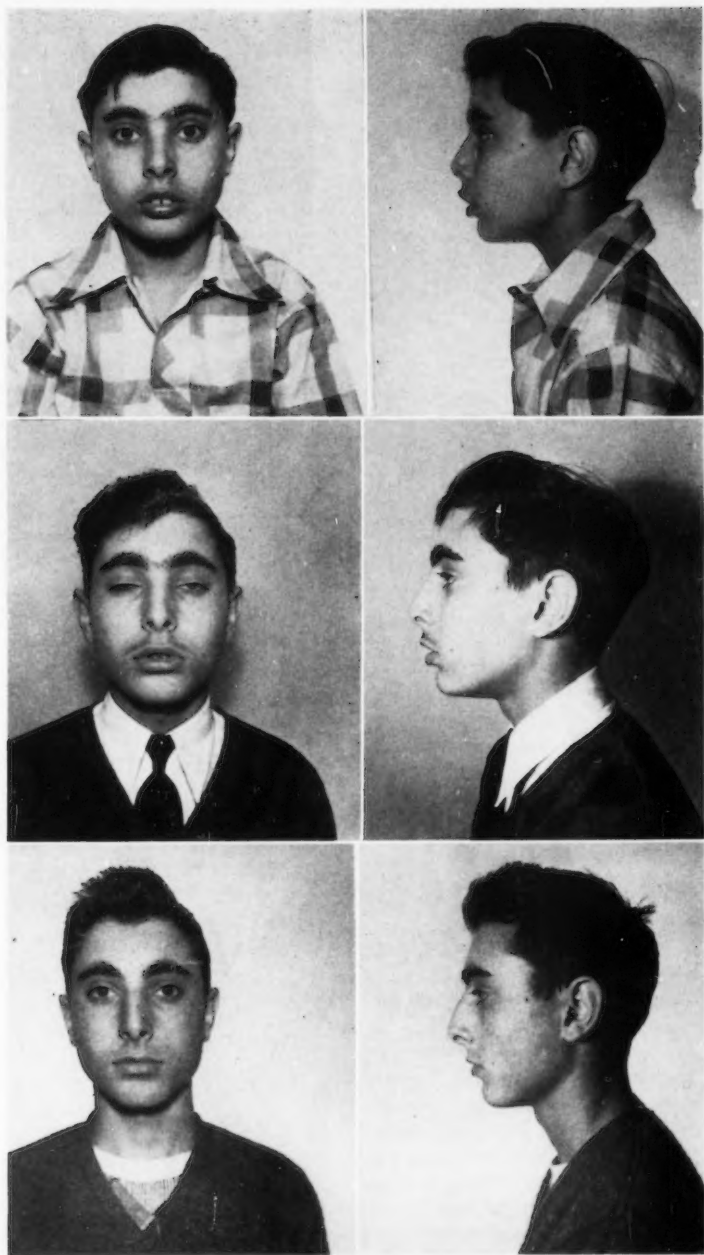
Fig. 9. Above, original photographs; middle, at end of active treatment; bottom, at the end of retention.

Fig. 10. Seven years after retention.

The findings in this case bear out almost completely the findings reported in the first cephalometric appraisal of treated cases by the staff at Illinois, published in 1938, namely:

1. Tipping is the predominant movement.
2. In all cases in which elastics were worn there was a disturbance of the occlusal plane.
3. There is a tendency for the occlusal plane to return following treatment.
4. Axial inclination of teeth, disturbed by orthodontic management, tends to correct itself following treatment.
5. There seems to be a definite correlation between success in treatment and growth.

The second case (M.R.) is also a male, age 13-6-3, at the onset of treatment. The case is classified as a Class II, Div. 1 Sub. The left side is in a full Class II relation, while the right side is somewhat forward of a Class I. The upper incisors are in severe overjet with an increased overbite. The lower incisors are in supraocclusion. Facial musculature is hypertonic. Case presents a somewhat protrusive type dentition.

Figure 11 is a tracing of the lateral head x-ray, at beginning of treatment; the facial photographs are in Figure 12, and in Figure 13 are the models at the beginning of active treatment.

The case was treated with a complete edgewise mechanism with all the teeth banded including the second molars. Treatment in this case was carried out in a more or less orthodox manner. Anchorage was not prepared. However, approximately from four to six months were used in establishing a good lower arch which consisted of leveling the occlusal plane and correcting nearly all rotations. Slight tip back bends to reverse the curve of Spee were used in the lower arch and the arch was tied back. In achieving the above some expansion was resorted to.
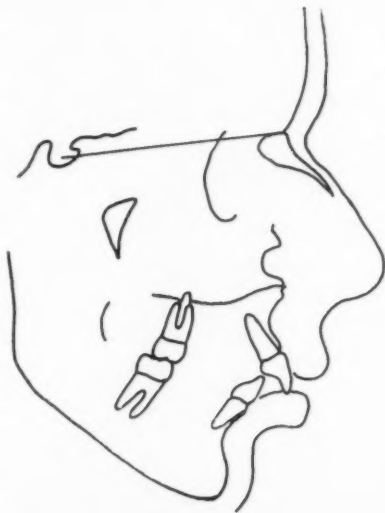

Fig. 11.

Fig. 12.

In the meantime, bracket control and some rotations were taken care of in the upper arch.

The next phase consisted of correcting the mesiodistal relationship. This was accomplished as follows: The upper archwire was cut on each side mesial to the canines. Hooks for intermaxillary elastics were soldered to rest against the mesial side of the canine brackets. Distal second order bends were placed in the buccal arch segments which were then tied in the usual manner and Class II elastics started.

The anterior arch segment was left in place for lip protection.

I have employed this procedure in Class II cases or wherever the mesiodistal relationship requires correction for the past twenty years. The thinking behind this is as follows:

1. Class II intermaxillary elastics are not employed continuously.

2. Second order bends are placed and elastics worn in the buccal segments for two or three appointments of three to four weekly intervals.

3. The buccal arch segments are then removed, elastics discontinued, and the case allowed to settle, or relapse, for one or two appointments.

4. This reveals several things:

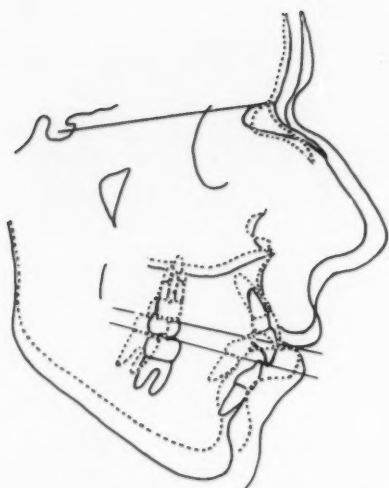(a) Anchorage is not strained and has a chance to recover dur-

Fig. 13.

Fig. 14. Before treatment and at the end of active treatment.

ing this brief rest period.

(b) Adverse distal tipping of the upper teeth is prevented.

(c) The relations of inclined planes of the upper and lower teeth change to each other; often this change occurring during a growth period acts to jump the bite. This saves much tooth movement.

5. After the rest period the arch segments are then replaced, second order bends checked, and intermaxillary elastics worn.

6. This procedure also serves as an excellent check on whether the patient is wearing elastics as instructed. If elastics are worn correctly, a space nearly always opens, distal to the upper laterals.

7. This process is repeated several times until the buccal segments are locked in correct mesiodistal relation. The upper incisors are then retracted and placed in their correct positions. Figure 14 shows tracings of the case at the beginning and the completion of active treatment and reveals the following:
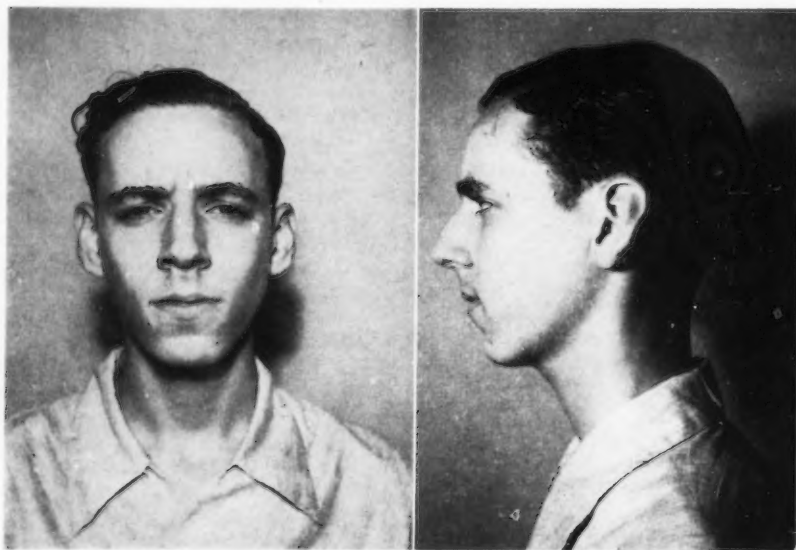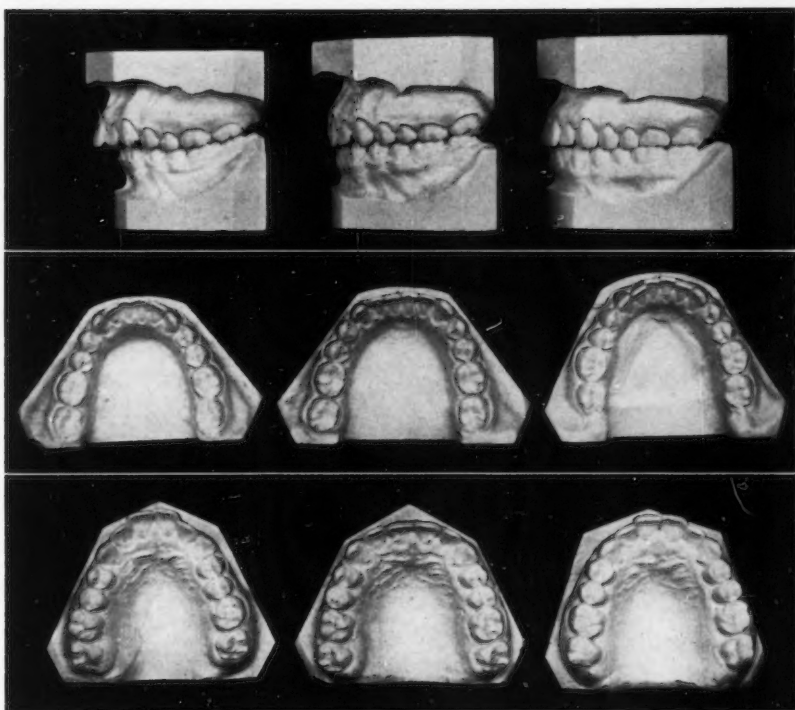

Fig. 15.

Fig. 16. Left to right, original models, end of active treatment, and sixteen years after completion of treatment.

1. Correction of the mesiodistal relationship.

2. Considerable overall growth with maxillary and mandibular growth in a downward and forward direction.

3. The lower incisor has improved its axial inclination from 100.5° to lower border in the original, to 92° at end of active treatment.

4. The lower molar has a more upright position. Any existing tipping is due to reducing the curve of Spee.

5. The occlusal plane has not been tipped. Note the nearly parallel relationship.

6. Nasion has moved forward while the nasal floor has descended in a parallel manner.

7. The upper molar has moved downward while maintaining the same relative axial inclination. This may be ascribed to the influence of the inclined planes. The incisor is relatively more upright.

Photographs at end of active treatment are seen in Figure 15.

Figure 16 shows models of the case sixteen years after the completion of treatment and approximately fourteen years after removal of retention. The four third molars were removed two years prior to making these models.

Figures 17 and 18 represent composites of tracings made before starting treatment and sixteen years after the completion of active treatment, a
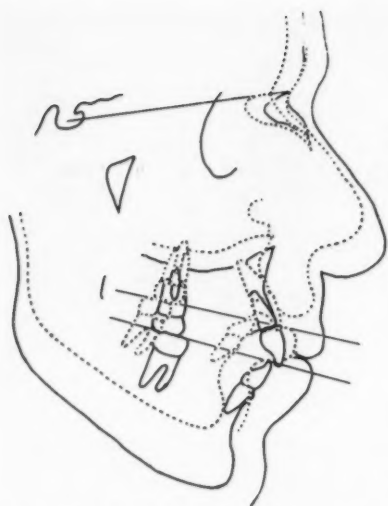
Fig. 17. Tracings before treatment and eighteen years later.

span of eighteen years, and reveals the following:

1. The excellent overall growth.

2. Practically parallel occlusal planes.

3. The close paralleling of the axes of the incisors and molars.

4. The upper incisor is tipped lingually.

5. Note the forward movement of nasion as well as the parallel descent of the nasal floor.

Final photographs are illustrated in Figure 19.

SUMMARY

The analyses of these two cases show striking similarities: both show excellent growth changes during the active treatment period and evidence of continued excellent growth long after treatment; both were treated without extraction.

The first case, L.L., had its dentition subjected to severe turmoil in the process of setting up anchorage. The second case, M.R., was not subjected to the process of setting up anchorage.
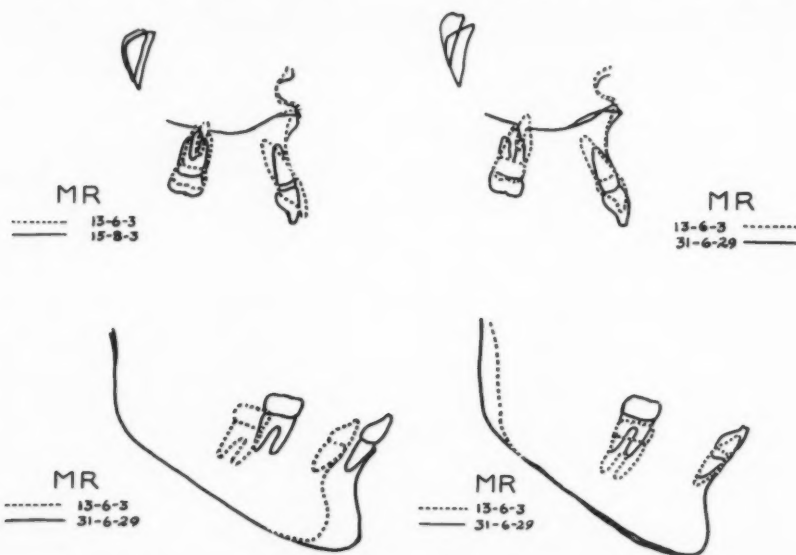
In the final assessment the results

Fig. 18. Above, maxillary superposition and below, mandibular superpositions.

Fig. 19.

were strikingly similar. The occlusal plane in the first one was completely upset and ultimately returned to a position practically parallel to the original case before treatment.

The occlusal plane in the second case was maintained nearly parallel throughout treatment and was found parallel, or nearly so, to the original case many years after treatment.

In the second case, after sixteen years without appliance support, the only evidences of relapse are broken contacts at the lower left central and upper right central, and a slight buccal movement of the lower left first molar. There does not appear to be any root resorption evident in the second case on intraoral x-rays taken sixteen years after treatment. The first case showed some slight resorption about the roots of the upper and lower incisors.

It would appear, therefore, that our greatest ally is the angel on our shoulder, growth. It also appears that setting up anchorage does not appear to offer enough advantages to justify its use.

These findings are the answer to my reluctance to give full credence to the cephalometric findings in angular measurements at the beginning of treatment, especially between the ages of nine and twelve years.

The basic angles may remain the same or nearly the same, but the potential of the pattern in a spatial relationship is not known for many years. It behooves us to explore this potential to its utmost.

I am fully aware that one case proves little in orthodontics. However, were we to explore more adequately the potentials in the pattern, keep adequate treatment and follow-up records, it is not unreasonable to suppose that we may find many cases exhibiting the same or similar response to like treatments.

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Relating The Mandible To The Maxilla In Treatment Of Class II Malocclusion

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The problem of making the upper and lower teeth fit together properly is one which has interested orthodontists for many years. Yet our clinical efforts, generally speaking, amount to little more than establishing a cusp and groove relation of the teeth. Considering the fact that more anatomic parts than teeth are involved this is substantially less than the best. In Class III treatment, seeking a good cusp and groove relation is apt to result in a fairly accurate jaw relation but in Class II treatment (and even in Class I) the mandible may be displaced slightly forward on one or both sides. The displacement is often too small to be detected using lateral head x-rays and it is likely to be overlooked clinically because muscles adapt to the new position. Sometimes this adaptation is temporary and the result is relapse of molar relation or dual bite. Other times it is quite permanent resulting in a convenience or protrusive bite which may or may not cause trouble later. There are times when these troubles are beyond the operator's control but often they can be avoided by having a little more respect for centric relation. If the majority of Class II malocclusions are to be thoroughly corrected, it is necessary not only to have a rather exacting objective, but also to check frequently during treatment to see that it is being attained.

It is the purpose of this paper to present what I feel should be the objective in Class II treatments as far as

jaw relation is concerned, and to suggest several methods for attaining it.

In order to achieve the best in jaw relation it is necessary to consider the position which the mandible assumes when vigorous muscle forces are being applied, for example, during the act of swallowing or during the final phase of the closing stroke in mastication. To illustrate this point, consider the recent work of Paul Hayes[1] on surgical correction of Class III malocclusion. Numerous investigators have observed that the mandibular rest position and the occlusal position does not always coincide (Fig. 1 A). There may be several millimeters difference between the two positions in some cases while in others there is little or no translational movement from rest to closure. Dr. Hayes has found this analysis useful before surgical correction of Class III malocclusions. It has been a common observation that many patients develop an open bite after such an operation and until recently no satisfactory explanation has been offered. Hayes observed that open bite develops in the patients whose rest position and occlusal position differ considerably while it does not occur in the cases where the two positions coincide. When the teeth are wired together and healing is allowed to take place with the condylar segments in rest position (Fig. 1B) away from the support of the articular eminence, an open bite will result because, when fixation is removed and function begins, the condyle seeks the support of the fossal slope and as a result the mandible assumes a more posterior
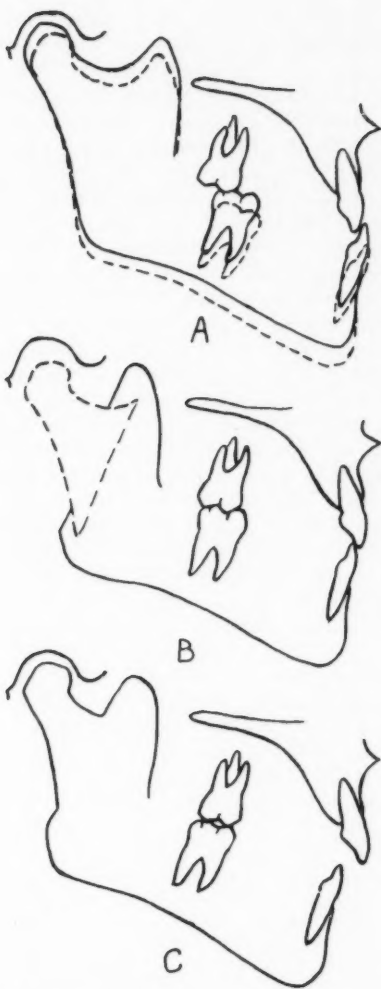
Fig. 1. Open bite develops after surgical correction of Class III malocclusion when healing takes place with condylar segment in rest position. From Dr. Paul Hayes.

position (Fig. 1 C). Dr. Hayes is now devising a method of securing the condylar segment in functional position, while healing takes place, in order to prevent open bite in such cases.

This observation illustrates another point which is important in relating the jaws. The condyles must have the support of the articular eminence if the mandible is to function normally. This is not meant to imply that the temporomandibular joint bears heavy stress. Robinson[2] has schematically analyzed the forces acting on the joint and this analysis has been expanded by Page.[3] Page noted that the resultant force of the closing muscles is approximately parallel to the fossal slope and because of this he believes that only moderate stress would be directed against the fossal bone no matter how ponderous the force that operates against the teeth. Many believe that the temporomandibular ligament assumes a substantial share of the stress in this area. Therefore, when we say that condyles must have a bearing point, we simply mean that both condyles must be against the anterior slope of the fossa when teeth are in occlusion if jaws are to be properly related.

Next it is important to consider the extent to which the mandible is retruded in normal function. There are a number of observations which indicate that the mandible reaches maximum retrusion, or nearly so, in normal function. Consider, for example, the cinefluorographic studies of Jankelson.[4] In speaking of the relationship between centric relation and swallowing he says, "The vigorous retrusion of the tongue explains why the mandible was inevitably carried into maximum retrusion during involuntary deglutition when the path of closure was free of occlusal interference and clarifies the common observation that in those cases where the mandible is prevented by cuspal interference from attaining centric occlusion, it goes to that position after interference is removed."

Sleichter's[5] study of seventy-one dry skulls and thirty-three living persons

shows that the amount of retrusion from centric is very limited. Less than one fourth cusp retrusion was the rule on the living subjects while it was only slightly more on the dry skulls.

Posselt[6] has shown that if extreme movements of the mandible are recorded graphically in the median plane a characteristic figure is obtained (Fig. 2). In addition, these boundary movements can be repeated exactly, a factor which would be of immense value in relating the jaws if the centric position were always on the border movement path. There is considerable controversy over this point, however. McCullum and Granger, for example, would favor point D while Beyron[7] and Posselt and many others would favor a position about 1 millimeter anteriorly. The important thing to remember is that the centric position is very close to the most retruded position.
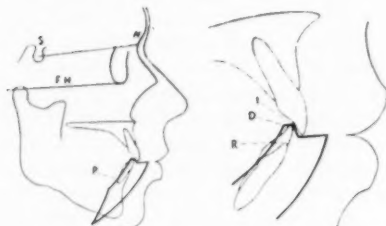

Fig. 2. Border movements of the mandible. From Beyron.

Another study of interest in this connection was made by the author. It has been observed that about eighty per cent of adults can retrude slightly beyond the intercuspal position. In an effort to determine whether this was true for children, accurate records were kept on one hundred seventy children between the ages of five and fifteen years. Seventy of the cases examined were untreated Class I malocclusions and one hundred were untreated Class II malocclusions. The average age of both groups was twelve years. In check-

ing the retruded position the patient was seated upright in the chair and instructed to open and close as the mandible was held in retrusion. Care was taken not to have the patient exceed hinge range which usually means not more than one half to three fourths inch opening at the incisors. It was found that seventy-three per cent of the Class II malocclusions and seventy-six per cent of the Class I cases could not retrude beyond intercuspal position. Those cases in which retrusion was possible could usually retrude less than one fourth of a cusp.

Even though most studies seem to indicate that there is a preferred mandibular position during function and that this position is very close to the most retruded position, it is conceivable that a range of anteroposterior positions is possible if the articular eminence is favorably formed. For example, the condyle could be supported in several positions on a fossal slope such as that illustrated in Figure 3 A while only one position would be possible with the slope illustrated in Figure 3 B. But recognizing that a range of positions is possible in some individuals, one should consider how function might differ in protrusion and retrusion.

Perry[5] has observed in an electromyographic study of the masseter and temporal muscles that the working side temporal initiates the closing movement in normal occlusions while in some Class II, Division I malocclusions the masseter was the first to give

A   B

Fig. 3.

recordable action potentials. His explanation of this seems perfectly logical when he states, "Perhaps the steeper curves of Spee and potentially retrognathic mandibles might necessitate a forward thrust of the mandible to obtain a more functional occlusion." Thus it seems probable that at least one characteristic of a protrusive bite is that closing muscles are contracting in abnormal sequence. Very probably the external pterygoid is overactive too.

From the clinical standpoint the protrusive bite is generally believed to be undesirable. Joint problems are quite common among adults with this relation. The only trouble is that this type of relation is not very clearly defined and about the only way to diagnose it accurately is to place flat splints over the occlusals of the upper or lower teeth or take teeth out of occlusion for several hours with a bite plate. If the mandible settles back to a more posterior position, undoubtedly it should function there.

The rest position analysis is not always accurate in such cases. Rest position may be stable from an electromyographic standpoint but for clinical purposes it cannot always be trusted. To illustrate this, consider the case in Figure 4. This patient had a long history of temporomandibular joint trouble; she could retrude her mandible about one half cusp but otherwise had an apparently normal occlusion. A rest position headplate was taken before insertion of a removable occlusal splint which allowed her to bite in a more retruded position. The solid line shows this position. After eight hours of wearing the splint another rest position headplate was taken. This position is shown by the dotted line. Since the joint pain disappeared whenever the removable splint was worn, it seems logical to conclude that the more retruded rest position was the true one. One weakness of the rest
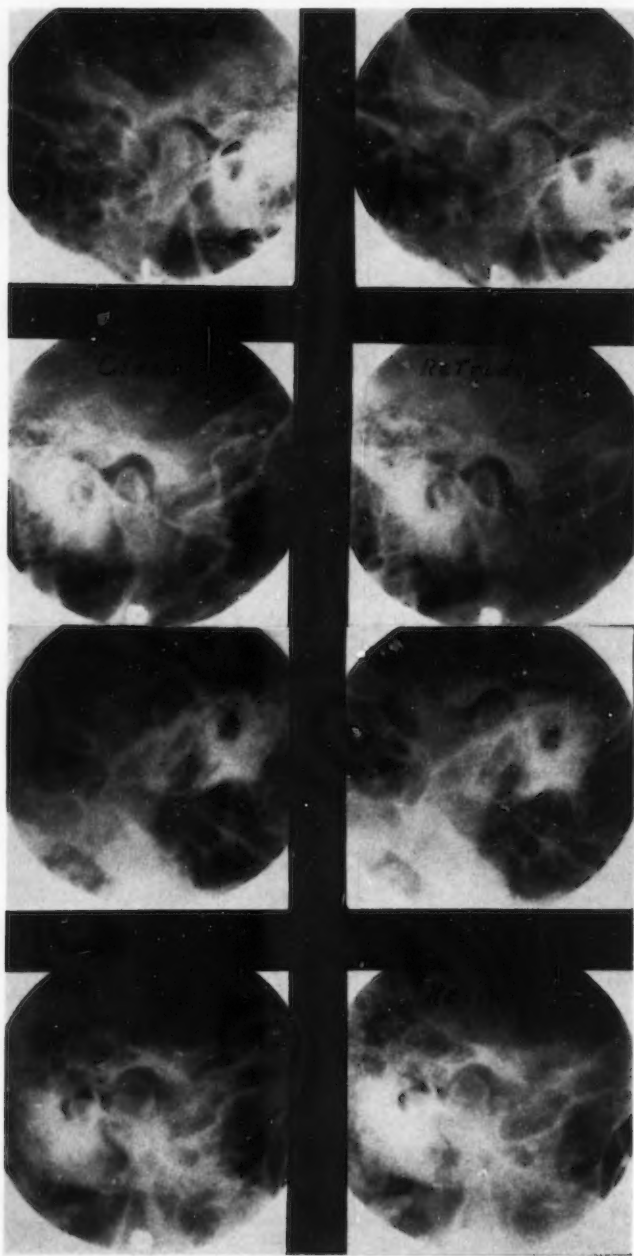

Fig. 4.

position analysis is that a protrusive bite is not always detected.

As previously implied, the retruded position may not always be reliable either. There are some who contend that condyles will be displaced posteriorly if jaws are related in this manner. The amount of displacement possible is said to depend on how much space is available posterior to the condyle when the mandible is in centric relation. Others contend that retruding the mandible places the condyles in correct position, that there is an upward and forward movement against the fossal slope because the temporomandibular ligament guides them to that position.

In order to help settle this argument temporomandibular joint x-rays were taken of three groups of patients. The technique for taking the x-rays is similar to that described by Updegrave[9][10] except that the patient sits upright and a head positioner of the author's design is used. As many as six x-rays can be obtained on one eight by ten film without moving the head. Naturally there is some distortion because of the angle at which they are taken but, since the head does not move, the distortion would be the same in each picture. A retruded wax bite is

taken first. With this in place the patient is positioned for the x-ray of the left joint. The wax bite is then removed and the teeth brought to natural closure for the next picture. This procedure is repeated for the right side making four pictures for each patient.

The first group consisted of ten patients whose mandible could not be retruded beyond the intercuspal position. As might be expected, no difference was observed between the retruded and closed position (Figs. 5 and 6), but there was often a large space posterior to the condyle when the mandible was in retrusion indicating that the temporomandibular ligament probably does limit the posterior movement. Naturally, the old clinical practice of retruding the mandible is ideal for relating the jaws in this type of case and the hinge axis registration is most accurate when the articulator is used.

In the next group were ten cases whose mandibles could be retruded beyond intercuspal position. All were adults with excellent occlusions and exceptionally healthy mouths. No tendency for the condyles to move upward or upward and forward against the articular eminence was observed in any of their x-rays. Instead, one condyle showed no measurable change in position while the other moved away from the eminence (Figs. 7 and 8). The retrusion in all of the cases was predominantly unilateral and the amount the condyle moved back averaged about a millimeter. It seems that, while these patients do not function in what is commonly regarded as the most retruded position, the condyles are on their most retruded bearing points when teeth are in occlusion. The fact
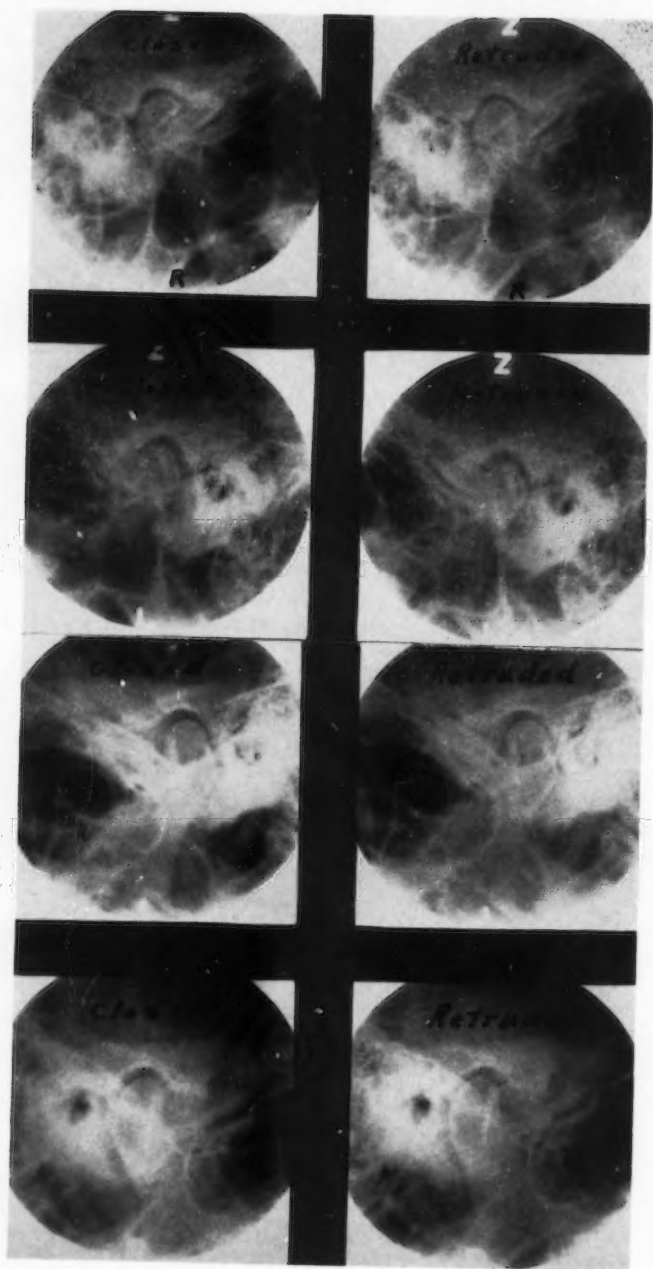
that the condyle moves backward away from the eminence rather than deeper into the fossa indicates that this is true. In this respect they are similar to those whose mandibles cannot be retruded beyond intercuspal position.

It would seem logical to regard this retruded position as abnormal because the mandible is in a non-functional position, at least on one side. Further proof of this is the observation that heavy biting force is not possible when the mandible is in this position. By placing the fingers at the angle of the mandible as the patient tries to exert biting pressure it will be observed that the masseter muscles do not contract vigorously until the teeth slide forward into occlusion. In addition to this, if teeth are taken out of occlusion temporarily with a bite plate, the mandible does not seek a more posterior position. This suggests that the occlusal position is correct and that no cuspal interferences are present. It seems reasonable to assume that the rest position analysis would be accurate for such cases providing it is not used with an articulator.

There are two main difficulties in using a rest position bite with the articulator. There is no way to locate an accurate center of rotation in the condyle and there is the possibility that movement from rest to closure will be translational. On the other hand, this type of case presents quite a problem for those who use the hinge axis registration because condyles are likely to be displaced posteriorly away from the fossal slope. The split hinge articulator seems to be a definite improvement over the rigid symmetrical types in common use but the possibility of dis-

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Fig. 5. Above, Treated Class II malocclusion. The patient cannot retrude beyond intercuspal position. There is no change in condylar positions when mandible is retruded.
Fig. 6, Below, normal occlusion. The patient cannot retrude beyond intercuspal position; there is no change is condylar positions when the mandible is retruded.

placing condyles posteriorly still exists. It seems probable that this abnormal retrusion is being obtained frequently in restorative dentistry by those who use conventional articulators with retruded wax bites and hinge axis registrations, but it is doubtful that such a relationship could ever be permanently established by orthodontic means. There is also clinical evidence to support this belief. For example, occlusal grinding has been performed on a number of such patients to eliminate the forward slide and the result has not remained stable. Shifting of teeth soon occurs so that retrusion is once again possible. In addition to this, it has been my experience that some cases cannot be treated to what is commonly regarded as the most retruded relation even though mandibular growth is good and great care is used in treatment.

Displacing condyles posteriorly should be of little concern in orthodontics, particularly in Class II treatment. Even in Class III treatment it is doubtful that a posterior displacement can be permanently established. Clinical support for this statement is the fact that orthodontists have been forcing the mandible into maximum retrusion for years in the treatment of Class III malocclusion without harmful effects. In fact there is less joint trouble in these patients than either the Class I or Class II.

The third group of cases consisted of ten treated Class II malocclusions. A different type of retrusion was found in most of these patients even though cuspal relations appeared to be similar to the normals when the mandible was retruded. In eight of the ten cases the condyles moved deeper into the fossae in an upward and backward direction. The movement was bilateral in eight cases but not always equal on each side. An example of this type of retrusion is shown in Figure 9. This type of patient, unlike the normal occlusions, can often exert heavy biting pressure while the mandible is retruded and, if the teeth are taken out of occlusion with a bite plate, the mandible will seek a more posterior position. It seems reasonable to conclude, therefore, that such patients do not have a normal bite even though cuspal relations are good. This protrusive relation is sometimes found in patients who have never been treated orthodontically but it is doubtful that such a relation should be considered normal. This type of case is shown in Figure 4.

To illustrate further that there is considerable variation in condylar movement when the mandible is retruded manually Figure 10 shows another case in which a considerable amount of retrusion was possible after treatment. X-rays (Fig. 11) show that both condyles move deeper into the fossae but the left (upper right photo) also moves away from the eminence.

When considering how far the mandible should be retruded as teeth come into occlusion, it seems important to remember that the majority of normal occlusions and the majority of untreated malocclusions have one thing in common. The mandibular condyle cannot be forced upward deeper into the fossa. When retrusion beyond intercuspal position is possible, the condyle merely moves backward away from the

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Fig. 7. Above, Normal occlusion. The patient can retrude beyond intercuspal position; left condyle moves away from the support of the articular eminence when the mandible is retruded. Fig. 8, Below, normal occlusion. The patient can retrude beyond intercuspal position; right condyle moves away from the support of the articular eminence when the mandible is retruded.
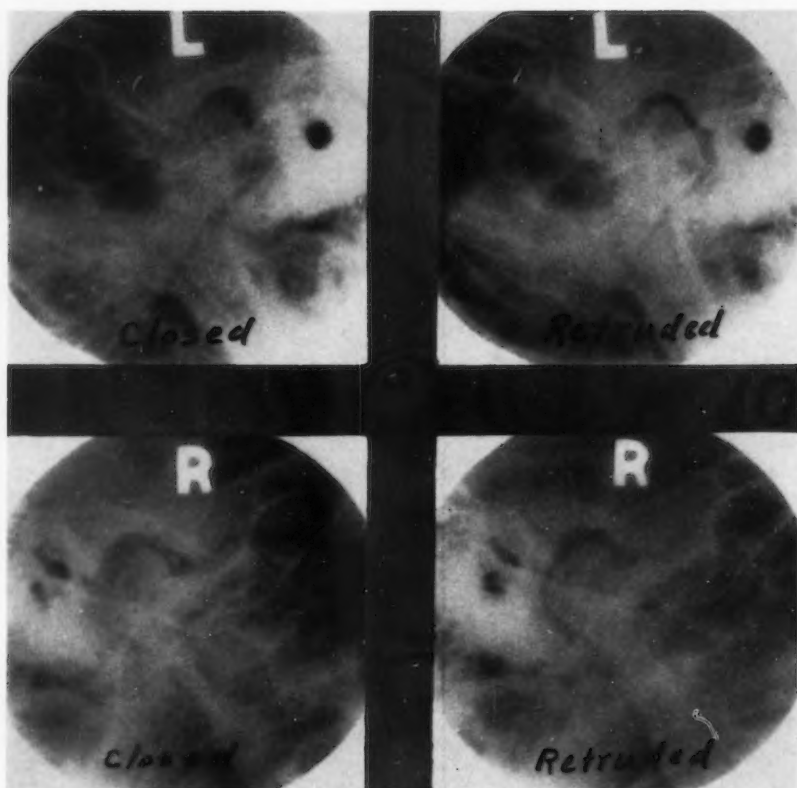
Fig. 9. A treated Class II malocclusion. The patient can retrude beyond intercuspal position; both condyles move deeper into fossae when the mandible is retruded.
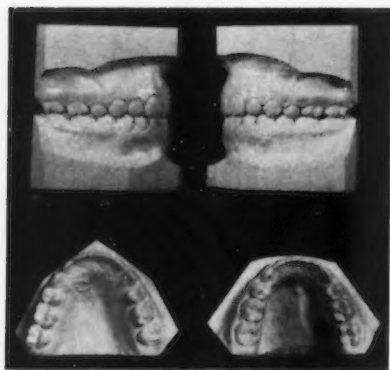

Fig. 10. Treated Class II malocclusion.

articular eminence, usually on one side only. It seems safe to say that when teeth are in occlusion the condyles should be supported on their most retruded bearing points on the fossal slope. The only difficulty is that neither the rest position nor manual retrusion is completely reliable in placing the mandible in this position.

With this as an objective, however, it is possible to use the retruded position as a clinical guide providing its limitations are recognized. It has the advantage of being accurate for the majority of patients of orthodontic age and there is also considerable merit
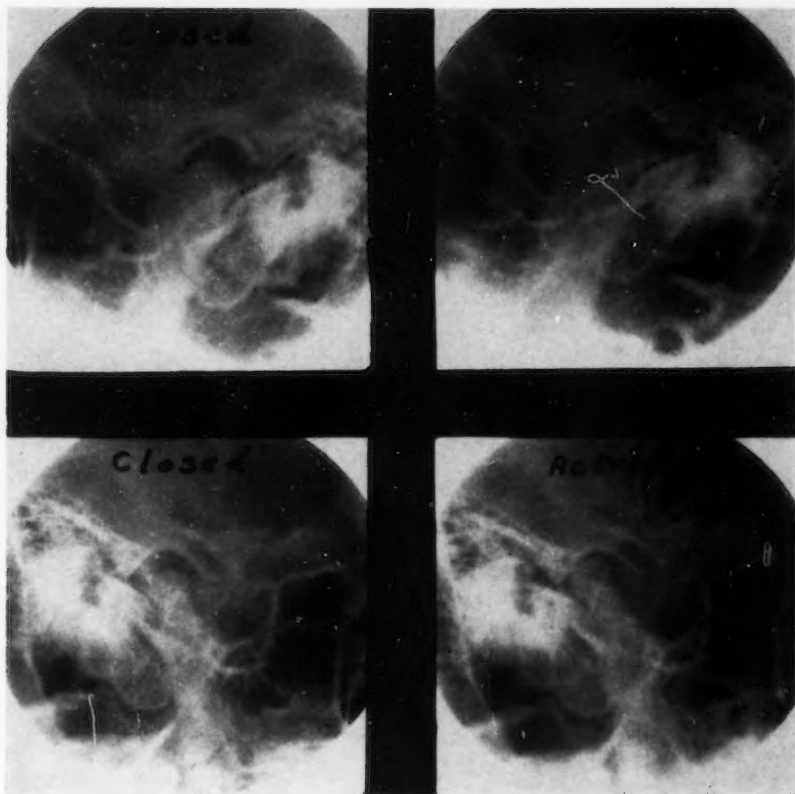
Fig. 11. The treated malocclusion shown in Fig. 10. The patient can retrude beyond intercuspal position; boh condyles move deeper into fossae and the left condyle also moves off the articular eminence. (Upper right photo)

in having teeth in contact when jaw relation is checked rather than several millimeters apart as they are in rest position. Another advantage is the ease with which buccolingual discrepancies are observed. Buccolingual positions of teeth affect the anteroposterior position of the mandible so it is important that they be observed. In Figure 12 is a case in which the mandible is displaced because of a unilateral buccolingual discrepancy. This type of faulty relation is rather common but it is likely to be overlooked unless the retruded position is used.

If the retruded position is to be used as a guide, it should be realized that only about seventy per cent of the cases can be treated to the retruded relation, and this requires more than an average amount of effort. The remaining thirty per cent will consist of some cases which have normal jaw relation even though slight retrusion is possible, some which are not good after treatment but which may improve as a result of good mandibular growth and others which will remain less than ideal. If the mandible can be retruded beyond the natural closing position
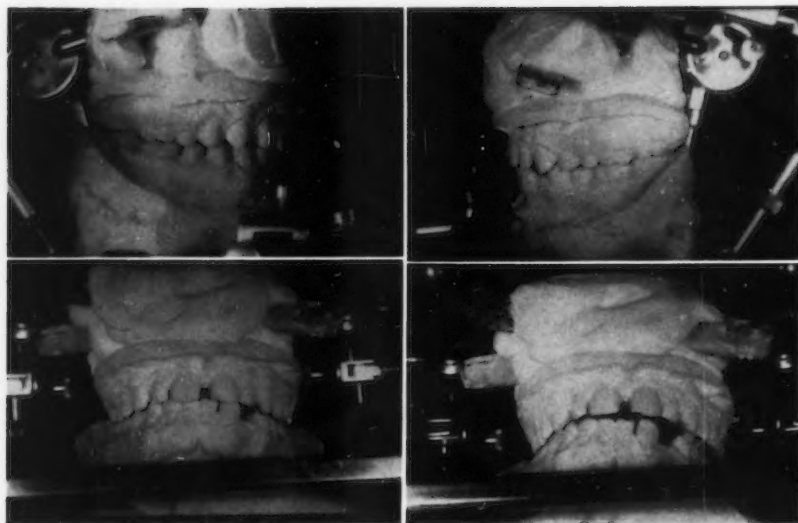
Fig. 12. Faulty buccolingual relation between upper and lower arches is seen when the mandible is retruded, lower right.

and we are interested in determining whether or not the relation is normal, it would seem advisable to make several additional observations. First, the amount of retrusion possible should be very slight. A great amount of retrusion would lead one to suspect that jaw relation is faulty. Second, a small amount of midline deviation is often normal when the mandible is retruded but, if the deviation is great and the posterior teeth are not related well buccolingually, the relation is certainly not normal. Third, if both masseter muscles contract vigorously when the mandible is retruded, chances are good that the condyles are supported on the articular eminence and that the mandible should function in this retruded position. Fourth, it would seem that the direction of condyle displacement as seen in temporomandibular joint x-rays would be helpful. Relation is probably normal if one condyle merely moves off the eminence rather than deeper into the fossa.

SUGGESTIONS FOR ATTAINING CORRECT
JAW RELATION IN CLASS II
TREATMENT

These suggestions are offered realizing that there may be other methods of obtaining the same results particularly in cases where patient cooperation is good. The important thing, however, is to have the objective in mind and to check at frequent intervals during treatment to make sure it is being attained. Generally speaking, these suggestions fall into three main categories: minimum use of Class II elastics, sectional treatment rather than en masse movement of teeth and coordination of arch widths.

First consider the non-extraction Class II treatment. In Figure 13 are the records of a boy eleven years of age. Notice that second molars have already erupted. This case was treated without Class II elastics except for three weeks toward the end of treatment when they were worn on one side only. In Figure 14 are the casts
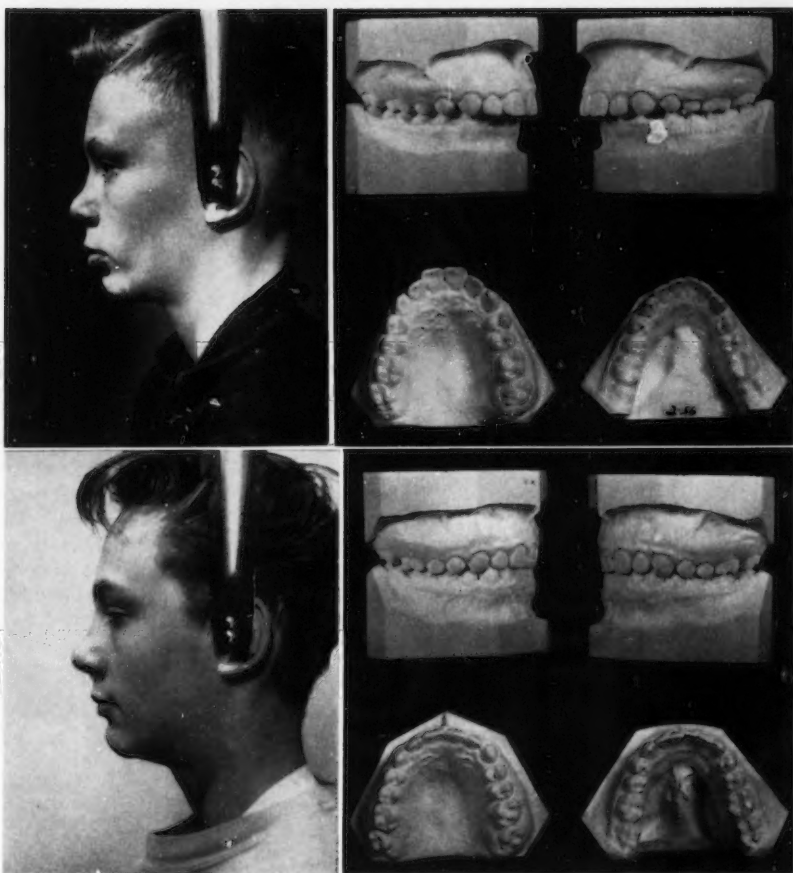
Fig. 13. Above, before treatment. Fig. 14, below, six months after retention.

and photos six months out of retention. This brings up the question of when these cases should be started. It is my belief that most Class II non-extraction cases need not be started before the late mixed dentition period when there are perhaps one or two deciduous teeth remaining. Early mixed dentition treatment with bite plate and headgear is all right if there is no objection to four or five years of care. But most of these cases require full appliance therapy after deciduous

teeth have been lost if satisfactory results are to be obtained.

In correcting a case of this kind, the upper first molars are banded and the headgear is worn until a Class I molar relation is established or until the headgear falls too far below the upper incisors (Fig. 15 top). The lower arch is also being leveled during this time with an edgewise arch. Particular attention is given to raising the first bicuspid in relation to the cuspid. After the upper first molar is tipped back, the

upper buccal teeth are banded and an .018 or .020 arch is tied in (Fig. 15 center). This uprights the molar so that the headgear does not fall below the upper incisors. Figure eight ties are used to close spaces and bring the buc-
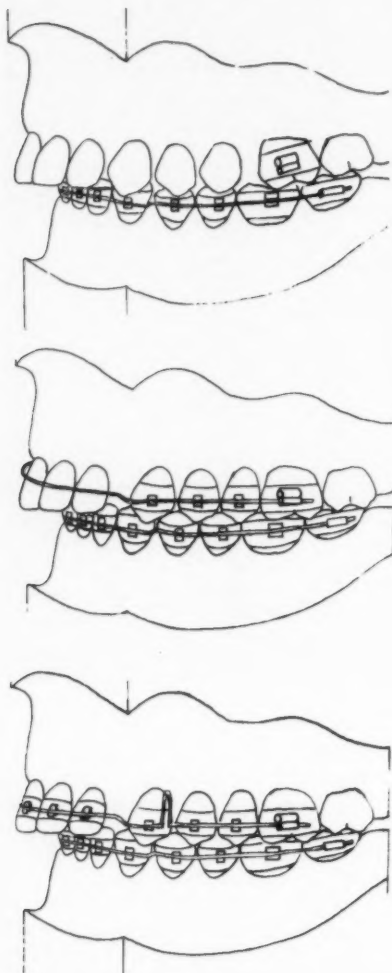
cal teeth back in Class I relation. By this time the lower arch is leveled and special attention has been given to arch form (Fig. 16). Care is taken to avoid widening across the lower cuspid area but the arch is purposely widened slightly in the first bicuspid area by means of a step-out bend. If the arch is too narrow across this area, cuspal interference will affect the anteroposterior position of the mandible. Conversely, care should be taken not to expand the upper arch or torque the bicuspids and molars buccally. After the buccal teeth are in Class I relation the upper incisors are banded and a space closing arch is used to bring them lingually (Fig. 15 below). The amount of labial torque used in this area varies with the inclination of these teeth. It may be advisable to band the upper incisors before they are brought lingually in order to prevent too much space from developing between them, but they are not tied into the arch until lingual movement is begun.

Fig. 16.

Fig. 15. Treatment of Class II non-extraction cases without intermaxillary elastics. Headgear is applied to the molars throughout treatment.
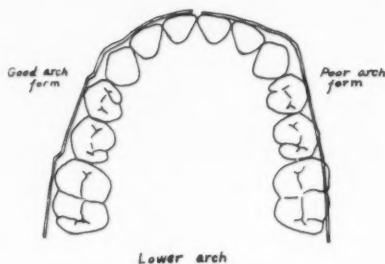
This type of treatment is not advocated on any case which has arch length problems or too much fullness around the lips. The operator is at the mercy of patient cooperation if this type of treatment is to be used and he must also be rather patient because some cases treated in this way will require nearly two years of care. But
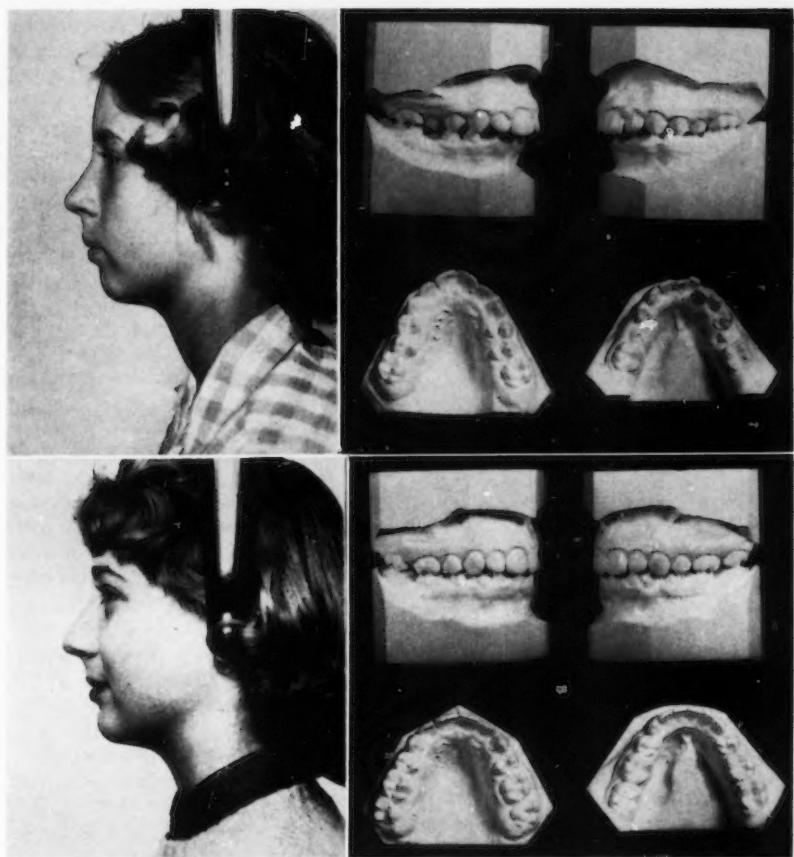
Fig. 17. Above, before treatment. Fig. 18, below, after treatment.

there are advantages in using this method of sectional tooth movement over the conventional Class II elastics and second order bends. There is less danger of displacing the mandible forward and it makes non-extraction cases out of many border-line extraction cases. Even where the lower arch offers sufficient anchorage for the use of Class II elastics, treating the buccal segments first seems to be a good plan because it allows the operator to feel his way, so to speak. If a good relation cannot be established between the up-

per and lower buccal teeth, it is quite certain that incisors cannot be moved to correct position. Even though this type of treatment may extend over a little longer time the appointments can be shorter so actual treatment time is not increased.

Consider next the treatment of a Class II four bicuspid extraction case. The records of such a case are shown in Fig. 17 and 18. Bands are placed on all teeth except the incisors at the beginning of treatment and space closing is started simultaneously in both arches
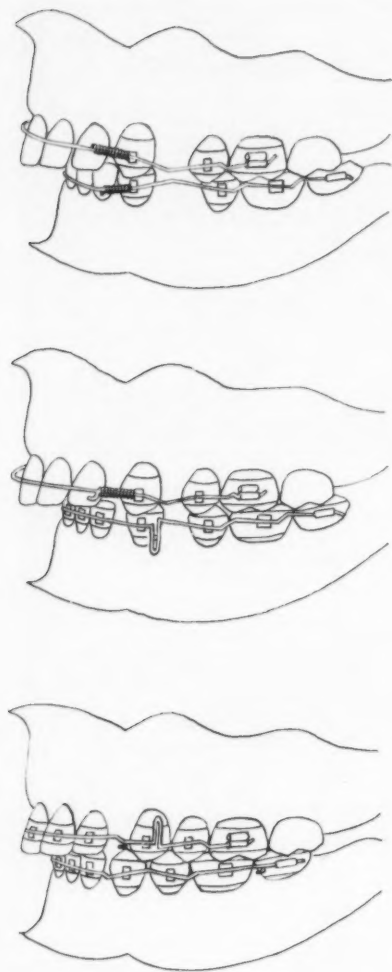
Fig. 19. Steps in treating Class II extraction cases. The headgear is applied to the upper molars throughout treatment. Molar relation is corrected before extraction spaces are closed.

(Fig. 19 top). Upper second molars are not banded unless a crossbite relation exists. A headgear is worn from the beginning of treatment. Notice the bend in both archwires at the site

of extraction; this is incorporated in each succeeding archwire as treatment progresses to keep roots parallel. When the lower cuspids are upright, the lower anteriors are banded and a space closing arch inserted as soon as possible Fig. 19 middle. Space closing continues in the upper arch as before. If the molar relation does not show signs of being corrected, a new upper arch is made with stops in front of the molar tubes which allows the arch to stand away from the upper incisors (Fig. 19 middle). Class II elastics are then worn during the day and the headgear at night until the upper first bicuspid space is closed and the buccal teeth are in Class I relation (Fig. 19 below). After the molar relation has been corrected, the upper anteriors are banded and space closing continues in both arches. When ideal arches are placed, special attention is given to coordinating arch widths as in the non-extraction case. Figure 18 shows the completed case. Active treatment was fifteen months. Examination of plaster casts only would indicate that this case is not quite as nicely treated as the extraction case shown in Figure 10. The overbite is a little deeper, the cusp and groove relation is not quite as ideal and the upper incisors are probably a little more upright than some would like; but the jaw relation is very good and from the functional standpoint I believe it is much better off than the other one.

This plan of treating the buccal segments first and correcting the Class II relation before all spaces are closed prevents the mistake of moving the lower cuspids and incisors too far back. For esthetic reasons it may be desirable sometimes to move the lower anterior segment as far posteriorly as possible but this can be accentuated in Class II extraction treatment. Sometimes I think it is necessary to settle for a little less in the way of esthetic improve-

ment to obtain a better relation of upper and lower teeth and jaws. Closing the spaces first and attempting to correct the Class II relation later is more likely to result in failure in the form of incomplete correction of molar relation, relapse of molar relation or protrusive bite.

Cases involving extraction of upper bicuspids only would seem to be less of a problem than either non-extraction or four bicuspid extraction cases but convenience bites are easily produced if attempts are made to move six upper anteriors back using only the bicuspid and molar on each side as anchorage. The headgear is important in this type of treatment and usually it is advisable to place a full appliance in the lower arch. Even though Class II elastics are not applied, the lower appliance is useful in reducing the overbite, correcting slight asymmetries and coordinating the arches buccolingually.

No matter how the Class II malocclusion is handled, it is well to remember that our job in treatment is to move teeth rather than the mandible, to guard against forward displacement rather than encourage it. With help from growth our work is made easier and often a good relation will be obtained in spite of our lack of care. But adequate mandibular growth alone does not always insure good jaw relation. It seems necessary to pay considerable attention to details and vary treatment according to the response if good results are to be obtained in many cases. Sometimes despite our best efforts we must settle for less than an ideal

relation and in those cases we can be thankful for adaptable muscles but it does not seem wise to depend too much on this kind of adjustment. It is comforting to have the protection of the proprioceptive system but it does not give us the right to ignore centric relation. If we are going to be fair with our patients we must regard functional efficiency as highly as we do esthetic improvement.

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Changes In Class II Malocclusions With And Without Occipital Headgear Therapy*

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Introduction

The current interest of the orthodontic profession in extraoral force is reflected by the numerous reports on its use which have recently appeared. The application of this force to the upper dental arch is considered by many to be the treatment of choice in Class II, Division 1 malocclusion, the most prevalent malrelation of the jaws. An important factor has been the realization that treatment of Class II cases without extraoral force can rarely be accomplished without some forward displacement of the lower dental arch.

As investigators come to place greater emphasis on objective measurement and less on clinical impression, the limitations and possibilities of a given appliance should become clear. Since it is generally accepted that there is no better method of accurately recording the changes due to facial growth and orthodontic therapy[1], roentgenographic cephalometry was used for the interpretation of treatment results. In any attempt to compare the conclusions of various investigators on this problem, the appliance used, the length of therapy, the type of sample and the degree of patient cooperation must be carefully evaluated. In this report, changes in a group of Class II patients treated with an occipital headgear will be compared with changes in a similar

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but untreated group at the end of a twelve-month period.

This uniform period of study eliminated some of the variability in the amount of growth occurring during the period of observation. The studies on extraoral force by Epstein[2], Graber[3], and King[4] are based on records taken fourteen months to four years apart and thus, some details of tooth movement and facial change may have been obscured. The ultimate importance of the changes observed in this report can be evaluated only by the future study of the dental relationships which have remained stable in these patients over a three or four year period. This project was designed to show as clearly as possible the changes in a group of patients treated with an occipital headgear appliance.

Material

Most cephalometric evaluations of orthodontic therapy have relied on studies of normal dentofacial growth and development to distinguish between treatment and growth changes. Investigations such as those of Brodie[5] and Björk[6] have provided the cornerstones of knowledge in this field. While studies in malocclusion cases have not established a growth pattern different from the normal, an investigator cannot predict in detail growth changes which will occur in the sample of cases he may have under treatment. The need to study an untreated group comparable in every way to the patients undergoing treatment was pointed out

Fig. 1, Typical malocclusions.

by Klein[5] in his study of extraoral force therapy.

Treatment Group

Patients were accepted into this study on the basis of possessing the following characteristics:

1. A Class II, Division 1 malocclusion. The severity of Class II molar relation varied from cusp to cusp occlusion to extreme cases in which the upper molars were more than a whole cusp forward (Fig. 1). Even in the less severe cases, the Class II relation was noted to be present in the canine and premolar areas.

2. An occlusion in the mixed dentition stage of development.

3. A lower dental arch in acceptable alignment and in good relationship to the mandibular base.

4. A malocclusion not complicated by prematurely lost deciduous or permanent teeth.

The mean age of the twenty-nine

cases in the treatment sample was 10 years 4 months at the beginning of treatment and consisted of: eighteen males, ranging from 8 years 9 months to 11 years 11 months of age, and eleven females, ages ranging from 8 years 3 months to 11 years 1 month.

Control group

The control group was assembled from the case records of the Philadelphia Center for Research in Child Growth, through the courtesy of Dr. W. M. Krogman. The enthusiastic cooperation received from this source gave our study a sample matching the treatment group in age, sex, dental stage and type of occlusion. Although an individual treated and control case cannot be directly compared, each treatment case was matched with a control case of the same age and sex to assure the comparability of the two groups. Both samples are composed of white Caucasian stock predominantly Mediterranean in origin.

The comparison, then, is between two groups of children with similar malocclusions, identical in sex and age. Subsequent annual evaluations will be made of the changes in both groups, thereby increasing our knowledge of the extent to which the dentofacial pattern can be altered.

APPLIANCE THERAPY

The intraoral appliance consisted of bands with edgewise attachments placed on the upper first permanent molars and the four upper incisors. A .021 x .025 archwire was used with hooks for attaching the headgear distal to the central incisors. Since all of the upper teeth were to be moved posteriorly with as little change in axial inclination as possible, it was important to have torque control over the upper incisors; the edgewise arch was placed with active lingual root torque in the anterior region. Stops

Fig. 2.

on the archwire mesial to the molars consisted of short sections of push springs slightly activated by Russell locks. This permitted ease of adjustment in changing the relative amount of force directed against the molars and incisors. *No* appliances were placed in the lower dental arch in any case.

The headgear itself is a commercially fabricated appliance that is light and easily adjusted (Fig. 2). Cloth straps pass both above and below the ear from a rigid plastic section on the cheek, and active force is supplied by elastics attached both to the plastic section and to hooks linked on the archwire. The patients reported that the appliance was reasonably comfortable and that no difficulty was en-

Fig. 3, This patient is typical of those in whom the position of the lower headstrap in relation to the ear prevented any higher angle of pull.

countered in sleeping with it in place. It was noted that adjustment was limited because the position of the lower strap passing beneath the ear prevents an effectively high angle of pull in some patients. (Fig. 3)

The treatment objective was to produce the maximum amount of desirable change in the shortest period of time, while keeping the appliance uncomplicated and not in need of frequent adjustment.

The excessively long period of treatment required by therapeutic methods stressing minimum tooth movement and maximum reliance on growth has been cited as a serious deterrent to satisfactory patient cooperation, optimum treatment results and efficient office management[8]. Therefore, treatment was directed at producing distal bodily movement of the upper teeth and correction of any rotation and spacing in the upper anterior segment.

PATIENT COOPERATION

It was known from the start that patient cooperation was essential, and therefore a method of checking this factor was incorporated into the design of the experiment. Charts designed for the easy recording of hours of daily headgear wear (Fig. 4) were at-

Fig. 4. The lower time chart has been filled in by a patient for a three week period; the upper unmarked chart is stapled to the envelope in which the headgear is kept.

tached to the envelope in which the removable portion of the appliance was kept. The recorded hours were checked and tabulated at each patient visit. It was repeatedly stressed to each patient and parent that accuracy in keeping these records was far more important than merely showing a good record. After considerable experience with these charts it was felt that we had a reliable and accurate method of recording patient cooperation.

Patients were instructed to wear the headgear appliance a minimum of twelve hours a day and more if possible. The average amount of headgear wear varied in individuals from ten to fourteen hours per day with an overall average of 12.3 hours. It was noted that with few exceptions once a pattern of headgear wear had been established for an individual, the average number of hours per day did not vary greatly during the treatment period.

METHOD OF MEASUREMENT

Lateral films taken in the Broadbent-Bolton cephalometer were the basis for all measurements on both treatment and control samples. The initial film and that taken one year later in each individual were traced according to standard cephalometric procedures and measurements made by direct comparison of the two tracings.

For this study, the tracings were superimposed on a non-growing area of the cranium rather than on a plane determined by points which move with growth. This was done by utilizing the line originally described by Keith and Campion[9] and introduced into roentgenographic cephalometrics by De Coster[10]. The line is formed by the anterior border of sella turcica, the planum, the superior surface of the ethmoid plate and the inner surface of the frontal bone (Fig. 5). It has
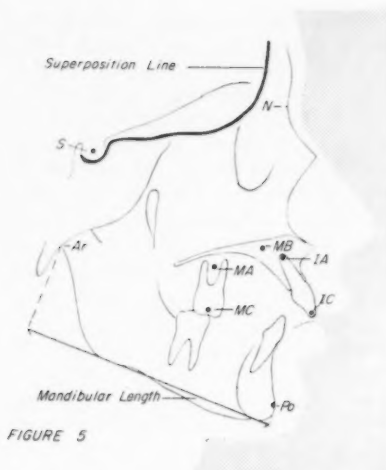
FIGURE 5

Fig. 5. The location of points used for
measurement and the cranial base line used
as the basis of superposition in this study.
The points were duplicated on subsequent
tracings by superimposing contours of the
individual teeth and jaws.

been utilized by Björk[11] and can be
consistently located in serial films. The
entire contour of the line can be super-
imposed on films taken after seven
years of age, giving a good basis of
orientation for comparative purposes.
In some cases, difficulty was encoun-
tered locating the line in the ethmoid
plate area. It was noted that orienta-
tion could be made more consistent
also by superimposing on the line which
extends from basion superiorly and
forward along the lesser wing of the
sphenoid to the cranial base.

Linear millimeter measurements
were used to determine the change in
position of the features studied here.
The use of angular readings for this
purpose tends to be less exact because
of the many variables which may af-
fect an angle. A decrease in the size
of the angle SNPo, for instance, might
mean that point Po moved backward,
but it could also mean a forward or
superior movement of point N. Angles
which are smaller, such as the SN-
upper molar angle, are even more
susceptible to this sort of difficulty in
interpretation.

In comparing the increments meas-
ured in this study with those of another
group, the age range, time span and
cephalometric technique used must be
borne in mind. Superposition of trac-
ings with registration on the SN plane
at sella as employed by Björk[11] would
be essentially the same, while the
registration at nasion used by Lande[12]
and Steiner[13] would greatly reduce the
horizontal anterior measurements.
Registration by the methods of Broad-
bent[14] or Ricketts[15] would show the
same proportional changes in the aver-
age case, but would reduce both hor-
izontal and vertical measurements.
Since we superimposed a non-growing
area and compared treated and un-
treated cases, no assumption concern-
ing amount or direction of growth was
necessary.

Points A and B, the subjects of much
recent cephalometric investigation,
were not included here. It was found
that point pogonion gives a more ac-
curate indication than point B of the
position of the anterior portion of the
mandibular body. The location of
point A yielded no new information
since both the upper incisor and the
maxillary body positions were meas-
ured directly. Observations in treated
cases showed a marked thickening of
the labial alveolar process due to lingu-
al movement of the upper incisors
(Figs. 10 and 12) and thus, later
thinning of the bone on which point
A is located may be expected. The
posttreatment changes in point A posi-
tion will be one of the important ob-
servations to be made on these patients
in subsequent reports.

The effect of occipital headgear
treatment was determined by measur-
ing changes in position of the follow-
ing points (Fig. 5):

1. MC and MA, the crown and the root apex of the maxillary first permanent molar, horizontal measurement.

2. IC and IA, the crown and the root apex of the maxillary central incisor, horizontal and vertical measurement.

3. MB, drawn near the center of the hard palate outline, indicating the location of the maxillary body, horizontal measurement.

4. Po, the anterior mandibular body, horizontal and vertical measurement.

Each of these points was drawn on a tooth or jaw to represent the position of that portion of the dentofacial complex at the time of the initial film. The outlines of the same individual structures seen in subsequent films were then superimposed on the original and the point reproduced by tracing. The exact location of any point on the original tracing is not critical for only the movement of the point is measured, indicating movement of the structure on which the point is located. The only point which was not easily and consistently reproduced was MB (maxillary body) because of the difficulty in visualizing anterior nasal spine and nasal floor contour and the changes in alveolar contour during the period of changing dentition and orthodontic treatment. The original facial plane (NPo) was the vertical axis on which all positional changes were based; horizontal changes were measured at right angles to this plane.

Two additional measurements were made showing growth over which the therapy was not expected to have any effect:

5. Length of the line from sella turcica to nasion.

6. Length of the mandible; measured between points Po and Ar (defined by Björk[6]). This is the effective mandibular length as employed by

Blair[16] and is a modification of Wylie's[17] method.

During the course of this study most of the tracings were done twice to check the limits of accuracy and it was determined that no measurement less than the nearest whole millimeter could be repeated consistently, as pointed out by Graber[18]. Since all films were taken using the same technique, the use of a correctional scale was not indicated (Higley[19]).

FINDINGS OF CONTROL GROUP

In reporting the lineal changes, the discussion is centered on the mean value or average behavior of the point in question. This procedure has been criticized when applied to certain types of data in the orthodontic literature as ignoring the individual pattern and presenting only an unreal average pattern. The use of average values is justified here because the variables affecting the measurement have been held to a minimum and the readings from most of the individual cases follow rather closely the mean trend.

The changes occurring over twelve months in the group of untreated Class II malocclusions are shown in Table I.

Fig. 6 is a composite showing the mean changes occurring within this group. It indicates that the mandible grew forward somewhat more than the maxilla and upper face and that the dentition, both upper and lower, moved forward at least as much as the lower jaw. In this group it was observed that anteroposterior relationships within the dentition remained constant for both the erupted teeth and the unerupted bicuspid and cuspid tooth buds. No significant changes in occlusion occurred.

It would be unwise to make any generalizations about dentofacial growth and development from a one-

TABLE I
CHANGE DURING ONE YEAR IN UNTREATED CLASS II CASES

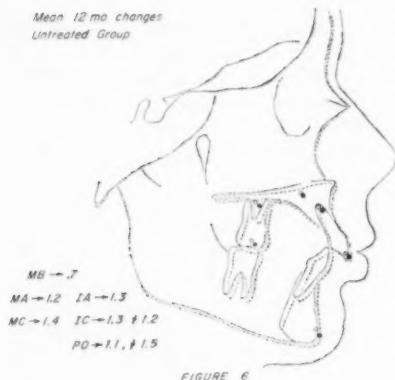|		Mean (mm)	S.D. (mm)	Range (mm)
FORWARD CHANGES	Molar crown	1.4	.7	0 to 3
	Molar apex	1.2	.9	0 to 3
	Incisor crown	1.3	.8	0 to 3
	Incisor apex	1.3	.9	0 to 3
	Maxillary body	0.7	.7	0 to 2
	Pogonion	1.1	1.1	—1 to 3
DOWNWARD CHANGES	Incisor crown	1.2	.6	0 to 3
	Pogonion	1.5	1.1	0 to 5
LENGTHENING CHANGES	Sella to nasion	0.9	.6	0 to 2
	Mandible	1.7	1.0	0 to 5

Fig. 6. A graphic construction of the changes recorded in Table 1. It shows the average growth changes over one year in 29 untreated Class II (1) cases with an initial mean age of 10.3 years.

year study of twenty-nine cases. However, the slight increase in mandibular prominence which was noted is consistent with the findings of Björk[6] and Lande[12]. If these mean growth changes occurred in every Class II patient under treatment, it would seem that a relatively small amount of occlusal alteration and distal pressure on the upper arch could disturb the synchronous forward movement of the dentition and allow improvement in arch relationship to occur. Our dilemma is that these changes do not occur in every case. The extremes in favorable and

unfavorable growth occurring in the untreated sample as shown in Fig. 7, would almost certainly have shown a wide difference in response to an identical orthodontic treatment procedure.

CLINICAL RESPONSE OF TREATMENT GROUP

Clinically, the headgear was effective in changing the molar relationship to Class I. Only four cases in the study did not attain full molar correction in 12 months time and nearly all the patients showed a substantial decrease in incisal overjet. Fig. 8 shows the original and one-year progress models on several of the patients.

In the hope of finding factors to explain the wide difference in the speed of clinical response, the cases were divided into three groups on the basis of treatment time. Placement in the rapid, intermediate or slow group depended on the number of months required for correction and on the amount of original discrepancy in molar relationship. Information which was analyzed for each group included the sex, chronological age, developmental age (from wrist film analysis) and dental maturity. The type and severity of facial skeletal deviation producing the Class II and the prevalence of this condition in other members of the immediate family were also recorded. None of these factors showed

Control H.G.
11-23-53 —
12-3-54 ····

Control F.L.
11-12-51 —
10-25-52 ····

MB → 2

MA → 2   IA → 3
MC → 3   IC → 3, ↓1
       Po → 3, ↓2

MB → 0

MA → 0   IA → 1
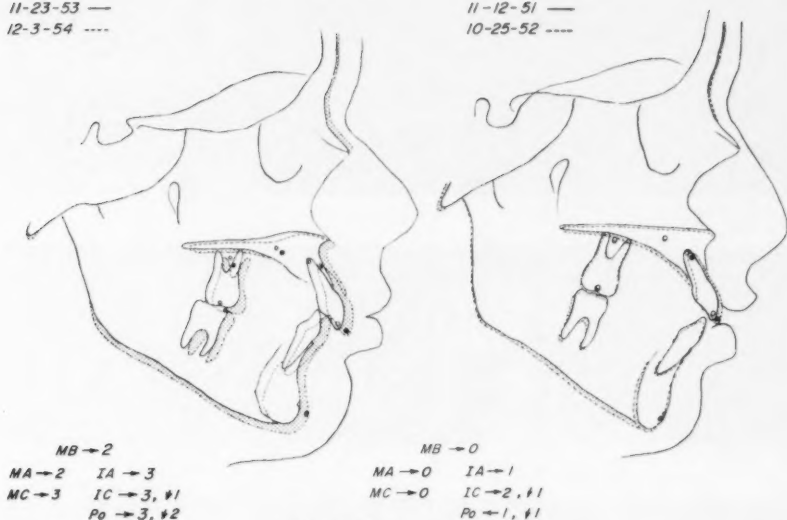MC → 0   IC → 2, ↓1
       Po ← 1, ↓1

FIGURE 7

Fig. 7. Tracings of two individual untreated cases demonstrating extremes in the amount and direction of facial growth during one year. Marked differences in response to orthodontic treatment could be expected.

any significant difference among the three groups. From the variability seen in this study, any trends which might exist among these factors could be demonstrated only on a very large treatment sample.

As analysis of the study proceeded, the difference between the groups in growth and cooperation became apparent and data on these factors is shown in Table II:

Upper facial growth (S to N) was not critical to treatment speed, but

the fast treating group averaged twice as much mandibular growth as the slow. This simply reconfirms what has been said countless times about the beneficial effects of mandibular growth during the treatment of Class II malocclusion. From the data recorded here it would not be possible to predict when this growth would occur. If the study of various maturation criteria eventually leads to the prediction of facial growth timing, the efficiency of orthodontic treatment can be greatly increased.

TABLE II

SIGNIFICANT FACTORS IN SPEED OF TREATMENT RESPONSE

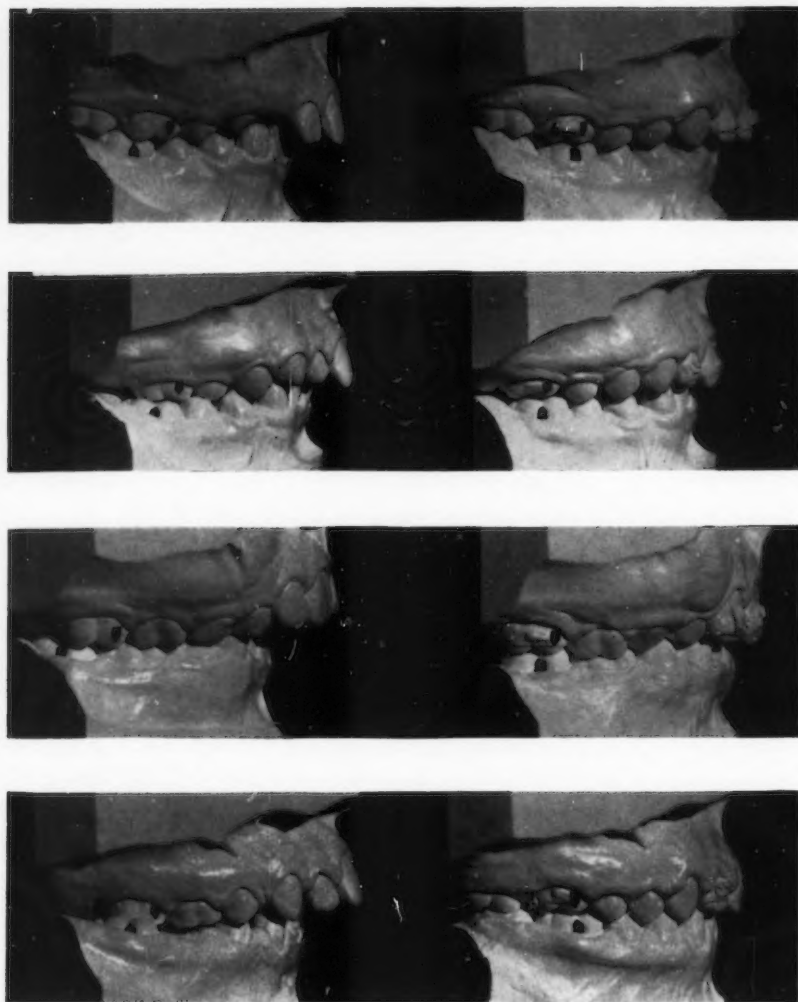|		Rapid Group	Intermediate Group	Slow Group
GROWTH	S to N	1.0 mm	0.9 mm	1.0 mm
	Mandible	2.4 mm	1.4 mm	1.2 mm
COOPERATION	Hours day	12.9 hrs.	12.2 hrs.	11.9 hrs.
	Inconsistent	0 %	13 %	37 %
	No. cases	10	11	8

Fig. 8. Changes after one year of treatment.

Data on cooperation were obtained from the time charts described before and show that the average number of hours of headgear wear did not differ greatly among the groups. Although a slight trend exists, the difference between the mean hours of the fast and slow group was not statistically significant.

The other factor which was noted on these charts is summarized in Table II as percentage of "inconsistent" wearing of the appliance. Some patients failed to wear the appliance regularly due to various circumstances including illness, local complaints involving ir-

TABLE III

CHANGE DURING ONE YEAR OF OCCIPITAL HEADGEAR TREATMENT

		Mean (mm)	S.D. (mm)	Range (mm)
FORWARD CHANGES	Molar crown	—2.3	1.7	0 to —7
	Molar apex	—1.6	1.0	0 to —4
	Incisor crown	—2.3	2.3	2 to —9
	Incisor apex	—1.1	1.0	1 to —3
	Maxillary body	0.1	0.8	1 to —1
	Pogonion	0.4	1.4	3 to —2
DOWNWARD CHANGES	Incisor crown	2.3	1.8	0 to 6
	Pogonion	2.6	1.6	0 to 6
LENGTHENING CHANGES	Sella to nasion	0.9	0.5	0 to 2
	Mandible (Po-Ar)	1.7	1.0	0 to 5

ritation or appliance adjustment, and other less plausible excuses. With a few patients it became obvious that the time charts were not honestly marked and questioning of patient and parent revealed breaks in routine which were then noted on the chart. The percentage recorded in Table II reflects the number of time charts in that group which showed lapses in headgear wear of three or more days. Wearing the headgear every day would appear to be very important for most effective treatment.

CEPHALOMETRIC FINDINGS

Changes occurring in the group of Class II, Division 1 cases treated with an occipital headgear for 12 months are shown in Table III.

Fig. 9 is a composite illustrating the mean changes recorded in Table III. In the table, minus values in the "Forward Changes" column indicate millimeters of distal movement. Molar crowns averaged 2.3 mm distal movement, and in one case, 7 mm of distal molar movement was recorded. Distal molar root movement averaged 1.6 mm; no mesial root movement was found in any case under treatment. Posterior movement of the central incisor crowns averaged 2.3 mm as did the molars, but individual cases showed more variation, ranging from 9 mm posterior movement to 2 mm anterior movement. Only 1.1 mm average pos-

Mean 12 mo changes
Headgear Treatment Group

M9 → .1
MA ← 1.6   IA ← 1.1
MC ← 2.3   IC ← 2.3, ↓ 2.3
Po → .4, ↓ 2.6

FIGURE 9

Fig. 9. A graphic construction of the changes recorded in Table 3. It shows the average treatment and growth changes over one year in the twenty-nine Class II (1) patients treated with occipital headgear.

terior incisor root movement was obtained, although individual cases showed up to 3 mm.

By comparing these values with the relatively small amount that pogonion came forward, 0.4 mm, one can readily see that by far the greatest part of the occlusal correction was due to distal movement of the upper teeth. Fig. 10 shows the twelve month changes in two of the cases. An important observation in both of these cases is that by using an appliance which moved the roots lingually, a significant posterior movement of the unerupted cus-

FIGURE 10

Fig. 10. Tracings of two patients undergoing headgear treatment. Posterior movement of the molars and incisors as well as the cuspid and bicuspid buds can be seen.

pid and bicuspid tooth buds was obtained. Upper tooth buds were moved posteriorly about the same distance as were the upper molar roots in every case.

NET CHANGES PRODUCED

While the values in Table III show what actually happened in the treatment group, the difference between the treatment and control groups is more important. Table IV shows this difference and reflects the treatment change without the growth change; that is, Table III values minus Table I values.

TABLE IV

DIFFERENCE IN ONE YEAR BETWEEN TREATED AND UNTREATED CLASS II CASES

		Difference	Significance
FORWARD CHANGES	Molar crown	—3.7	+++(<.01)
	Molar apex	—2.8	+++(<.01)
	Incisor crown	—3.6	+++(<.01)
	Incisor apex	—2.4	+++(<.01)
	Maxillary body	—0.6	+(.05)
	Pogonion	—0.7	+(.05)
DOWNWARD CHANGES	Incisor crown	1.1	++(.01)
	Pogonion	1.1	++(.01)
LENGTHENING CHANGES	Sella to nasion	0.0	0
	Mandible (Po-Ar)	0.0	0

Net 12 mo. Changes
Treatment Minus Control Group

MB ← 6
MA ← 2.8   IA ← 2.4
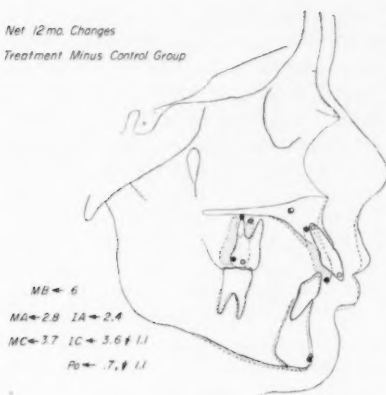MC ← 3.7   IC ← 3.6 ↑ 1.1
Po ← .7 ↓ 1.1

FIGURE 11

Fig. 11. A graphic construction of the differences between treatment and control groups as recorded in Table 4. The positions of the teeth and jaws under treatment are compared with the positions they would have occupied without treatment.

The degree of individual variation was such that treated and untreated cases could not be compared on an individual basis, but valid conclusions can be drawn from the statistical comparison of large enough samples. Fig. 11 is a graphic representation of the group differences as seen in Table IV. It shows where the teeth and jaws were as compared with where they might be presumed to have been without treatment.

Posterior movement of upper teeth, the primary goal of treatment, was well accomplished. The entire maxillary dentition, including both the erupted and the unerupted teeth, was about 3 mm farther back than it would have been without treatment.

It was hoped that this movement could be obtained without the excess upper incisor extrusion and increase in lower face height which often occur during Class II correction procedures. Incisor extrusion tends to increase the vertical overbite, which initially is often deep in a Class II case. The ex-

cessive downward movement of the chin is really an opening swing of the mandible, resulting in an inhibition of the normal forward chin progress. Even though this retardation is slight, it may accentuate the retrusive profile common in Class II malocclusion. The excess vertical movement found in this study was 1.1 mm for both the incisor and the chin. This resulted in a retardation of forward pogonion movement of 0.7 mm on the average. In the case shown in Fig. 12, where downward movement was 4 mm and mandibular growth was slight, a 2 mm posterior movement of pogonion occurred.

The lack of difference noted in the "Lengthening Changes" column of Table IV demonstrates that the areas measured were not affected in any way by treatment. The inhibition of forward chin movement was not due to any lessening in growth of the mandible,

Patient D.L.
2-15-57 ——
2-14-58 ----

MB ← 1
MA ← 2   IA ← 2 ↑ 3
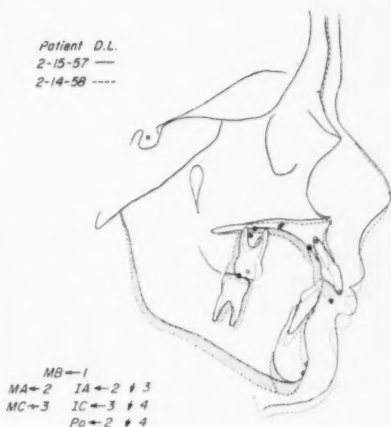MC ← 3   IC ← 3 ↑ 4
Po ← 2 ↑ 4

FIGURE 12

Fig. 12. Tracings showing progress in one headgear patient. The excess downward movement accompanying the distal movement has resulted in the hinging-open of the mandible. Pogonion has moved 2 mm distally from the original N-Po line.

but a difference in direction of mandibular growth. From present knowledge it seems doubtful that any treatment method could materially affect growth in length of the mandible.

The inhibition of forward growth of the maxillary body was only .6 mm and, as was noted, the location of the measurement point less certain than other points used. Nevertheless, observations in individual cases confirmed the trend, and an actual posterior movement and slight downward tipping of the maxilla (the palatal plane) was recorded in several cases. This was the same effect noted by Klein[8] in his report of cervical traction therapy.

Headgear therapy is, therefore, observed to affect the position of both the mandible and maxilla. The absolute size of these changes is very small when compared to changes in tooth position and they are not of any great assistance in the clinical correction of a Class II malocclusion. It is also apparent that in studies covering longer periods of time and less active treatment mechanics, these changes would be largely obscured by normal growth, if indeed they persisted at all.

DISCUSSION

The amount of distal tooth movement obtained in these cases was greater than that reported with the cervical type of extraoral force appliance. Klein, using the maxillary outline for superposition, reported 1 mm average distal upper molar movement, but probably would have recorded less if a cranial registration were employed. However, the effect of headgear force on the maxilla itself makes exact comparison difficult. A small amount of posterior movement was reported by Epstein in a few of his cases, and Graber and King found that in most cases a maintenance of the normal forward molar movement was all that could be expected.

Occipital headgear treatment appears to be capable of substantial tooth movement in very young patients for West[20] found an average of approximately 4 mm distal movement of upper deciduous molars. This measurement includes an increase equal to the amount of forward growth at nasion because of the superposition method. It is impossible to determine exactly what effect the length of therapy period or the degree of patient cooperation had on the findings of most treatment evaluation studies. However, until other evidence is forthcoming, I would agree with the conclusion of West that distal movement of upper teeth is best accomplished with an occipital headgear.

The amount of anterior movement of the upper dentition recorded in the untreated group points out the need for an appliance capable of distal tooth movement. The dentition came forward about 1.3 mm in one year, which was more than the forward growth at nasion. Even so, it would take five years to correct a moderate Class II case with 6 mm of molar discrepancy using an appliance capable of no more than a holding action. The possibility of tissue damage and loss of patient cooperation would make therapy of this length unacceptable to many.

To gain a more thorough understanding of the action of the occipital headgear, changes in occlusal plane angulation in relationship to other facial changes were examined. The plane was located on all the tracings by bisecting molar and incisal cusp height. While the angle of the occlusal plane to the anterior cranial base did not change in the untreated group, a mean downward tip of $2.8°$ ($\pm2.4°$) was noted in the treatment group. The scattergram in Fig. 13 shows that with an increase in occlusal plane tipping, a decrease in forward pogonion movement occurred; the correlation is high
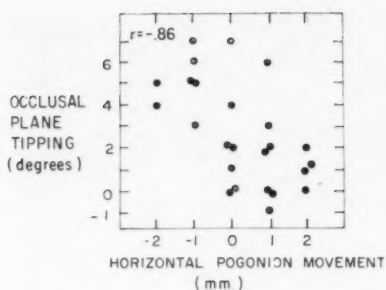
Fig. 13. A scattergram showing the degree of correlation between the horizontal movement of pogonion and tipping of the occlusal plane.

$(r = -.86)$.

This relationship was also observed by Tovstein[21] in studying the effects of intraoral Class II elastics on the occlusal plane. The elastic force produced a downward tip averaging between 4° and 7° and it could be inferred that this would be associated with a proportionately larger inhibition of forward chin movement. Ricketts[15] observed an increased inclination of the mandible in cases treated with Class II elastics. This same type of unfavorable change was noted by King in cases treated with cervical anchorage and a full or partial edgewise appliance. Klein found this effect when treating cases with the Kloehn[22] type of cervical anchorage.

Downward tipping of the occlusal and mandibular planes is therefore common in most Class II correction mechanics. The appliance therapy used in "preparation of mandibular anchorage" seems to be one means of avoiding this tendency. Stoner, et al.[23], in studying a group of cases treated by Tweed, found very little tipping action and little inhibition of forward chin movement. The use of Class III elastics and very high pull headgear are undoubtedly instrumental in this achievement. An important part of the profile improvement associated with this treatment is due to control of the downward tipping of the occlusal and mandibular planes.

APPLIANCE IMPROVEMENT

Clinical and cephalometric observation has been continued in some patients where longer therapy with the occipital headgear was necessary. The vertical overbite was not decreasing and, in many cases, normal downward growth of the upper molars was being restricted. In a few instances an actual open bite in the molar area was created. Analysis of this behavior of the teeth made the mechanics of the headgear clearer.

Fig. 14(a) shows the appliance used here in relationship to dentofacial structures as recorded in cephalometric films of patients wearing the headgear. The facebow is pulling at an angle superior to the occlusal plane, but a downward tipping of this plane was observed. The stippled area indicates the location of the maxillary dental roots and alveolar process, and the letter "M" is the geometric center of this mass. With "M" considered as the center of resistance to the pull of the facebow, the behavior of the teeth was exactly as might be expected. Even the position of the hook extending downward from the archwire tends to give an undesirable torquing action.

For those patients requiring additional treatment, the headgear has been modified as shown in Fig. 14(b). The hook has been moved forward, extending upward from the archwire and the direction of facebow pull has been raised, which requires a different type of head strap in most cases. On the basis of these observations, distal pull on the upper dentition should be aligned through "M", the center of the maxillary root mass, to avoid undesirable tipping movements. If opening of the bite is desired, the force should
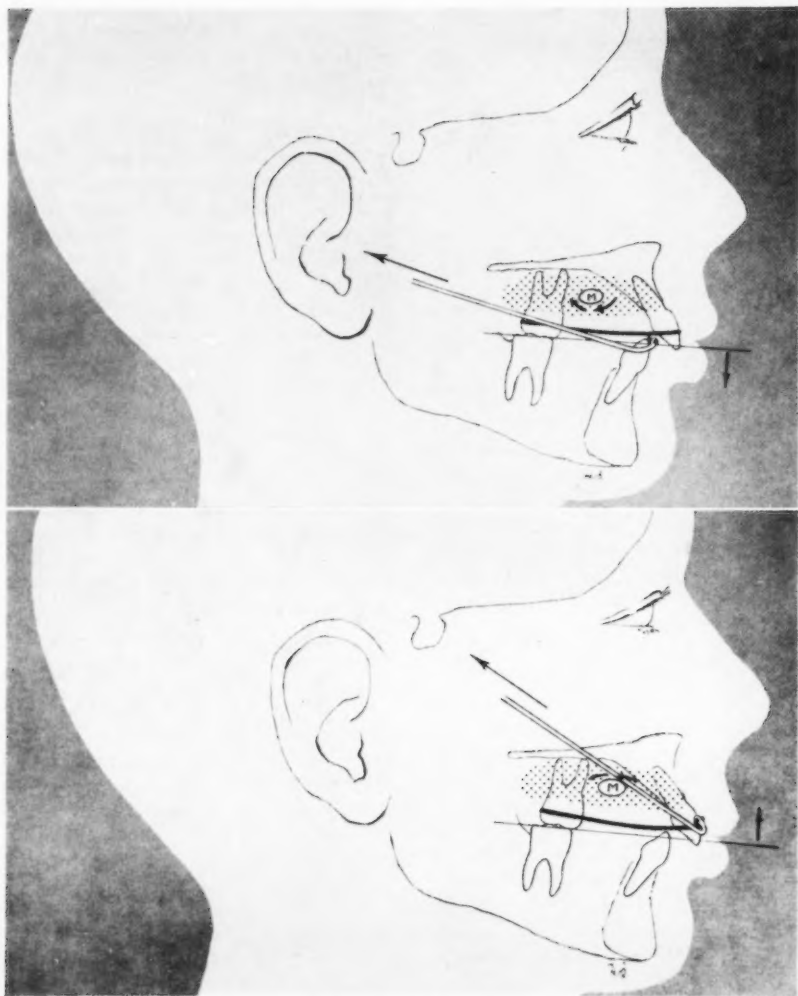
Fig. 14, above. The relationship of dentofacial structures to the occipital headgear appliance as recorded from lateral headfilms of patients wearing the appliance. The stippled area indicates the roots and alveolar process of the maxillary dentition and "M" is the center of this mass. Arrows indicate the movement as a resultant of the applied force. Fig. 14, below. A higher line of force and point of attachment would be indicated to correct excessive overbite and avoid downward tipping of the mandible. The amount of distal movement possible with this set-up has not been studied.

be aligned forward and superior to "M".

This type of "high-pull" headgear is currently coming into wide use in orthodontic practice, especially during therapy requiring reduction of incisor overbite. The initial treatment results are demonstrating the effectiveness of the appliance in upper incisor intrusion. Because a headgear appliance shows a wide variation in the relationship of the direction of pull to the teeth in different patients, a "high-pull" or any other type of headgear should be selected according to the individual and to the malocclusion.

Through the continued efforts of the orthodontic profession to objectively report treatment results obtained with the various appliance regimes, it will ultimately be possible to appreciate the therapeutic possibilities of every available appliance. Only in this way can the problems of each patient be met with the most ideal, permanent and economical form of treatment.

SUMMARY

A group of 29 mixed dentition, Class II, Division 1 patients were treated with an occipital headgear and compared with a closely matched group of untreated cases. Differences in dentofacial changes between the groups were analyzed at the end of one year utilizing lateral cephalometric films.

1. Molar relationships were corrected and incisor positions improved in nearly all the treated cases, largely by a substantial distal movement of the upper dentition. Most cases showed a marked distal position of the maxillary roots and unerupted tooth buds.

2. Comparison with the control group revealed some inhibition of forward maxillary growth and a slightly greater increase in lower face height. The dentition in the control group moved forward more than the upper face.

3. Regular daily wearing of the headgear and the amount of mandibular growth were shown to be the most important factors in obtaining a prompt treatment response.

4. Analysis of the mechanics of the headgear force used here suggested that changing the attachment and direction of pull in relation to the maxillary roots might improve the action of the appliance.

5. From comparisons with tooth movement reported in other studies, the occipital headgear appears to be the most effective appliance for moving upper teeth posteriorly.

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Line drawings should be prepared in India ink on white stock; the width of lines and the size of lettering should take into account the fact that most illustrations are reduced in size in the engraving process. Photographs should be sharp, glossy prints of adequate size, *unmounted and kept separate from the text*. At the discretion of the editor, illustrations will be reproduced either as single column cuts of approximately 2¼ inches in width, or as double column cuts of 4¾ inches in width. The height of the cut may vary, but contributors should keep in mind that proportionate reduction or enlargement of illustrations affects all dimensions, and that arrangement of material should be such that awkward proportions are avoided and no loss of clarity results.

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